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Letter dated 27 November 2001 from the Deputy Permanent Representative of the United States of America to the United Nations addressed to the President of the Security Council

I have the honour to draw your attention to the dual-use list issued on 27 November 2001 (see annex).

I should be grateful if you would have the text of this letter and its annex circulated as a document of the Security Council.

(*Signed*) James B. **Cunningham**
Ambassador

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Annex to the letter dated 27 November 2001 from the Deputy Permanent Representative of the United States of America to the United Nations addressed to the President of the Security Council

Dual-use goods and technologies

Contents

Page

List of dual-use goods and technologies

- General Technology and General Software Notes 3
- Category 1. Materials 4
- Category 2. Materials Processing 20
- Category 3. Electronics 39
- Category 4. Computers 51
- Category 5. Part 1 Telecommunications 62
- Category 5. Part 2 Information Security 68
- Category 6. Sensors and Lasers 72
- Category 7. Navigation and Avionics 96
- Category 8. Marine 102
- Category 9. Propulsion 110
- Annex 1 118
- Annex 2 125

Definitions of terms used in these lists 128

Acronyms and abbreviations 146

Statements of understanding and validity notes 148

DUAL-USE LIST

Note *Terms in "quotations" are defined terms. Refer to 'Definitions of Terms used in these Lists' annexed to this List.*

GENERAL TECHNOLOGY NOTE

The export of "technology" which is "required" for the "development", "production" or "use" of items controlled in the Dual-Use List is controlled according to the provisions in each Category. This "technology" remains under control even when applicable to any uncontrolled item.

Controls do not apply to that "technology" which is the minimum necessary for the installation, operation, maintenance (checking) and repair of those items which are not controlled or whose export has been authorized.

Note *This does not release such "technology" controlled in entries 1.E.2.e. & 1.E.2.f and 8.E.2.a. & 8.E.2.b.*

Controls do not apply to "technology" "in the public domain", to "basic scientific research" or to the minimum necessary information for patent applications.

GENERAL SOFTWARE NOTE

The Lists do not control "software" which is either:

1. Generally available to the public by being:

   a. Sold from stock at retail selling points without restriction, by means of:
      1. Over-the-counter transactions;
      2. Mail order transactions; or
      3. Telephone call transactions; and

   b. Designed for installation by the user without further substantial support by the supplier; or

   Note *Entry 1 of the General Software Note does not release "software" controlled by Category 5 - Part 2.*

2. "In the public domain".

Dual-Use List - Category 1 - ADVANCED MATERIALS

1. A. SYSTEMS, EQUIPMENT AND COMPONENTS

1. A. 1. Components made from fluorinated compounds, as follows:

a. Seals, gaskets, sealants or fuel bladders specially designed for "aircraft" or aerospace use made from more than 50% by weight of any of the materials controlled by 1.C.9.b. or 1.C.9.c.;

b. Piezoelectric polymers and copolymers made from vinylidene fluoride materials controlled by 1.C.9.a.:
   1. In sheet or film form; and
   2. With a thickness exceeding 200 µm;

c. Seals, gaskets, valve seats, bladders or diaphragms made from fluoroelastomers containing at least one vinylether group as a constitutional unit, specially designed for "aircraft", aerospace or missile use.

1. A. 2. "Composite" structures or laminates, having any of the following:

a. An organic "matrix" and made from materials controlled by 1.C.10.c., 1.C.10.d. or 1.C.10.e.; or

Note 1.A.2.a does not control finished or semi-finished items specially designed for purely civilian applications as follows:
   a. Sporting goods;
   b. Automotive industry;
   c. Machine tool industry;
   d. Medical applications.

b. A metal or carbon "matrix" and made from:
   1. Carbon "fibrous or filamentary materials" with:
      a. A specific modulus exceeding 10.15×10^6 m; and
      b. A specific tensile strength exceeding 17.7×10^4 m; or
   2. Materials controlled by 1.C.10.c.

Note 1.A. 2.b. does not control finished or semi-finished items specially designed for purely civilian applications as follows:
   a. Sporting goods;
   b. Automotive industry;
   c. Machine tool industry;
   d. Medical applications.

Dual-Use List - Category 1 - ADVANCED MATERIALS

1. A. 2. b. *Technical Notes*

1. Specific modulus: Young's modulus in pascals, equivalent to N/m^2 divided by specific weight in N/m^3, measured at a temperature of (296 ± 2) K ((23 ± 2)°C) and a relative humidity of (50 ± 5)%.

2. Specific tensile strength: ultimate tensile strength in pascals, equivalent to N/m^2 divided by specific weight in N/m^3, measured at a temperature of (296 ± 2) K((23 ± 2)°C) and a relative humidity of (50 ± 5)%.

Note *1.A.2. does not control composite structures or laminates made from epoxy resin impregnated carbon "fibrous or filamentary materials" for the repair of aircraft structures or laminates, provided the size does not exceed 1 m^2.*

1. A. 3. Manufactures of non-fluorinated polymeric substances controlled by 1.C.8.a.3. in film, sheet, tape or ribbon form:

a. With a thickness exceeding 0.254 mm; or

b. Coated or laminated with carbon, graphite, metals or magnetic substances.

Note *1.A.3. does not control manufactures when coated or laminated with copper and designed for the production of electronic printed circuit boards.*

1. A. 4. Protective and detection equipment and components not specially designed for military use, as follows:

a. Gas masks, filter canisters and decontamination equipment therefor designed or modified for defence against biological agents or radioactive materials "adapted for use in war" or chemical warfare (CW) agents and specially designed components therefor;

b. Protective suits, gloves and shoes specially designed or modified for defence against biological agents or radioactive materials "adapted for use in war" or chemical warfare (CW) agents;

c. Nuclear, biological and chemical (NBC) detection systems specially designed or modified for detection or identification of biological agents or radioactive materials "adapted for use in war" or chemical warfare (CW) agents and specially designed components therefor.

Note *1.A.4. does not control:*

a. Personal radiation monitoring dosimeters;

b. Equipment limited by design or function to protect against hazards specific to civil industries, such as mining, quarrying, agriculture, pharmaceuticals, medical, veterinary, environmental, waste management, or to the food industry.

Dual-Use List - Category 1 - ADVANCED MATERIALS

1. A. 5. Body armour, and specially designed components therefor, not manufactured to military standards or specifications, nor to their equivalents in performance.

Note 1 *1.A.5. does not control individual suits of body armour and accessories therefor, when accompanying their users for his/her own personal protection.*

Note 2 *1.A.5. does not control body armour designed to provide frontal protection only from both fragment and blast from non-military explosive devices.*

1. B. TEST, INSPECTION AND PRODUCTION EQUIPMENT

1. B. 1. Equipment for the production of fibres, prepregs, preforms or "composites" controlled by 1.A.2. or 1.C.10., as follows, and specially designed components and accessories therefor:

a. Filament winding machines of which the motions for positioning, wrapping and winding fibres are coordinated and programmed in three or more axes, specially designed for the manufacture of "composite" structures or laminates from "fibrous or filamentary materials";

b. Tape-laying or tow-placement machines of which the motions for positioning and laying tape, tows or sheets are coordinated and programmed in two or more axes, specially designed for the manufacture of "composite" airframe or missile structures;

c. Multidirectional, multidimensional weaving machines or interlacing machines, including adapters and modification kits, for weaving, interlacing or braiding fibres to manufacture "composite" structures;
Note *1.B.1.c. does not control textile machinery not modified for the above end-uses.*

d. Equipment specially designed or adapted for the production of reinforcement fibres, as follows:
1. Equipment for converting polymeric fibres (such as polyacrylonitrile, rayon, pitch or polycarbosilane) into carbon fibres or silicon carbide fibres, including special equipment to strain the fibre during heating;
2. Equipment for the chemical vapour deposition of elements or compounds on heated filamentary substrates to manufacture silicon carbide fibres;
3. Equipment for the wet-spinning of refractory ceramics (such as aluminium oxide);
4. Equipment for converting aluminium containing precursor fibres into alumina fibres by heat treatment;

e. Equipment for producing prepregs controlled by 1.C.10.e. by the hot melt method;

f. Non-destructive inspection equipment capable of inspecting defects three dimensionally, using ultrasonic or X-ray tomography and specially designed for "composite" materials.

1. B. 2. Equipment for producing metal alloys, metal alloy powder or alloyed materials, specially designed to avoid contamination and specially designed for use in one of the processes specified in Item 1.C.2.c.2.

Dual-Use List - Category 1 - ADVANCED MATERIALS

1. B. 3. Tools, dies, moulds or fixtures, for "superplastic forming" or "diffusion bonding" titanium or aluminium or their alloys, specially designed for the manufacture of:
   a. Airframe or aerospace structures;
   b. "Aircraft" or aerospace engines; or
   c. Specially designed components for those structures or engines.

1. C. MATERIALS

Technical Note

Metals and alloys
Unless provision to the contrary is made, the words 'metals' and 'alloys' cover crude and semi-fabricated forms, as follows:

Crude forms
Anodes, balls, bars (including notched bars and wire bars), billets, blocks, blooms, brickets, cakes, cathodes, crystals, cubes, dice, grains, granules, ingots, lumps, pellets, pigs, powder, rondelles, shot, slabs, slugs, sponge, sticks;

Semi-fabricated forms (whether or not coated, plated, drilled or punched):
a. Wrought or worked materials fabricated by rolling, drawing, extruding, forging, impact extruding, pressing, graining, atomising, and grinding, i.e.: angles, channels, circles, discs, dust, flakes, foils and leaf, forging, plate, powder, pressings and stampings, ribbons, rings, rods (including bare welding rods, wire rods, and rolled wire), sections, shapes, sheets, strip, pipe and tubes (including tube rounds, squares, and hollows), drawn or extruded wire;
b. Cast material produced by casting in sand, die, metal, plaster or other types of moulds, including high pressure castings, sintered forms, and forms made by powder metallurgy.

The object of the control should not be defeated by the export of non-listed forms alleged to be finished products but representing in reality crude forms or semi-fabricated forms.

Dual-Use List - Category 1 - ADVANCED MATERIALS

1. C. 1. Materials specially designed for use as absorbers of electromagnetic waves, or intrinsically conductive polymers, as follows:

a. Materials for absorbing frequencies exceeding 2 x 10^8 Hz but less than 3 x 10^{12} Hz;

Note 1 *1.C.1.a. does not control:*

a. Hair type absorbers, constructed of natural or synthetic fibres, with non-magnetic loading to provide absorption;

b. Absorbers having no magnetic loss and whose incident surface is non-planar in shape, including pyramids, cones, wedges and convoluted surfaces;

c. Planar absorbers, having all of the following characteristics:

1. Made from any of the following:

a. Plastic foam materials (flexible or non-flexible) with carbon-loading, or organic materials, including binders, providing more than 5% echo compared with metal over a bandwidth exceeding ±15% of the centre frequency of the incident energy, and not capable of withstanding temperatures exceeding 450 K (177° C); or

b. Ceramic materials providing more than 20% echo compared with metal over a bandwidth exceeding ±15% of the centre frequency of the incident energy, and not capable of withstanding temperatures exceeding 800 K (527°C);

Technical Note

Absorption test samples for 1.C.1.a. Note 1.c.1. should be a square at least 5 wavelengths of the centre frequency on a side and positioned in the far field of the radiating element.

2. Tensile strength less than 7 x 10^6 N/m^2; and

3. Compressive strength less than 14 x 10^6 N/m^2;

d. Planar absorbers made of sintered ferrite, having:

1. A specific gravity exceeding 4.4; and

2. A maximum operating temperature of 548 K (275°C).

Note 2 *Nothing in Note 1 releases magnetic materials to provide absorption when contained in paint.*

1. C. 1. b. Materials for absorbing frequencies exceeding 1.5 x 10^{14} Hz but less than 3.7 x 10^{14} Hz and not transparent to visible light;

Dual-Use List - Category 1 - ADVANCED MATERIALS

1. C. 1. c. Intrinsically conductive polymeric materials with a bulk electrical conductivity exceeding 10,000 S/m (Siemens per metre) or a sheet (surface) resistivity of less than 100 ohms/square, based on any of the following polymers:
   1. Polyaniline;
   2. Polypyrrole;
   3. Polythiophene;
   4. Poly phenylene-vinylene; or
   5. Poly thienylene-vinylene.

   Technical Note

   Bulk electrical conductivity and sheet (surface) resistivity should be determined using ASTM D-257 or national equivalents.

1. C. 2. Metal alloys, metal alloy powder and alloyed materials, as follows:

   Note *1.C.2. does not control metal alloys, metal alloy powder and alloyed materials for coating substrates.*

   Technical Notes

   1. The metal alloys in 1.C.2. are those containing a higher percentage by weight of the stated metal than of any other element.

   2. Stress-rupture life should be measured in accordance with ASTM standard E-139 or national equivalents.

   3. Low cycle fatigue life should be measured in accordance with ASTM Standard E-606 'Recommended Practice for Constant-Amplitude Low-Cycle Fatigue Testing' or national equivalents. Testing should be axial with an average stress ratio equal to 1 and a stress-concentration factor (K_t) equal to 1. The average stress is defined as maximum stress minus minimum stress divided by maximum stress.

1. C. 2. a. Aluminides, as follows:
   1. Nickel aluminides containing a minimum of 15 weight percent aluminium, a maximum of 38 weight percent aluminium and at least one additional alloying element;
   2. Titanium aluminides containing 10 weight percent or more aluminium and at least one additional alloying element;

   b. Metal alloys, as follows, made from material controlled by 1.C.2.c.:
      1. Nickel alloys with:
         a. A stress-rupture life of 10,000 hours or longer at 923 K (650°C) at a stress of 676 MPa; or
         b. A low cycle fatigue life of 10,000 cycles or more at 823 K (550° C) at a maximum stress of 1,095 MPa;
      2. Niobium alloys with:
         a. A stress-rupture life of 10,000 hours or longer at 1,073 K (800°C) at a stress of 400 MPa; or
         b. A low cycle fatigue life of 10,000 cycles or more at 973 K (700°C) at a maximum stress of 700 MPa;

Dual-Use List - Category 1 - ADVANCED MATERIALS

1. C. 2. b. 3. Titanium alloys with:
   a. A stress-rupture life of 10,000 hours or longer at 723 K (450°C) at a stress of 200 MPa; or
   b. A low cycle fatigue life of 10,000 cycles or more at 723 K (450°C) at a maximum stress of 400 MPa;
   4. Aluminium alloys with a tensile strength of:
      a. 240 MPa or more at 473 K (200°C); or
      b. 415 MPa or more at 298 K (25°C);
   5. Magnesium alloys with:
      a. A tensile strength of 345 MPa or more; and
      b. A corrosion rate of less than 1 mm/year in 3% sodium chloride aqueous solution measured in accordance with ASTM standard G-31 or national equivalents;

1. C. 2. c. Metal alloy powder or particulate material, having all of the following characteristics:
   1. Made from any of the following composition systems:
      Technical Note
      X in the following equals one or more alloying elements.
      a. Nickel alloys (Ni-Al-X, Ni-X-Al) qualified for turbine engine parts or components, i.e. with less than 3 non-metallic particles (introduced during the manufacturing process) larger than 100 µm in 10^9 alloy particles;
      b. Niobium alloys (Nb-Al-X or Nb-X-Al, Nb-Si-X or Nb-X-Si, Nb-Ti-X or Nb-X-Ti);
      c. Titanium alloys (Ti-Al-X or Ti-X-Al);
      d. Aluminium alloys (Al-Mg-X or Al-X-Mg, Al-Zn-X or Al-X-Zn, Al-Fe-X or Al-X-Fe); or
      e. Magnesium alloys (Mg-Al-X or Mg-X-Al); and
   2. Made in a controlled environment by any of the following processes:
      a. "Vacuum atomisation";
      b. "Gas atomisation";
      c. "Rotary atomisation";
      d. "Splat quenching";
      e. "Melt spinning" and "comminution;
      f. "Melt extraction" and "comminution"; or
      g. "Mechanical alloying";
   3. Capable of forming materials controlled by 1.C.2.a. or 1.C.2.b.;

1. C. 2. d. Alloyed materials, having all of the following characteristics:
   1. Made from any of the composition systems specified in 1.C.2.c.1.;
   2. In the form of uncomminuted flakes, ribbons or thin rods; and
   3. Produced in a controlled environment by any of the following:
      a. "Splat quenching";
      b. "Melt spinning"; or
      c. "Melt extraction";

Dual-Use List - Category 1 - ADVANCED MATERIALS

1. C. 3. Magnetic metals, of all types and of whatever form, having any of the following characteristics:

   a. Initial relative permeability of 120,000 or more and a thickness of 0.05 mm or less;
   Technical Note
   Measurement of initial permeability must be performed on fully annealed materials.

   b. Magnetostrictive alloys, having any of the following characteristics:
      1. A saturation magnetostriction of more than 5×10^{-4}, or
      2. A magnetomechanical coupling factor (k) of more than 0.8; or

   c. Amorphous or nanocrystalline alloy strips, having all of the following characteristics:
      1. A composition having a minimum of 75 weight percent of iron, cobalt or nickel;
      2. A saturation magnetic induction (B_s) of 1.6 T or more; and
      3. Any of the following:
         a. A strip thickness of 0.02 mm or less; or
         b. An electrical resistivity of 2×10^{-4} ohm cm or more.

   Technical Note
   'Nanocrystalline' materials in 1.C.3.c. are those materials having a crystal grain size of 50 nm or less, as determined by X-ray diffraction.

1. C. 4. Uranium titanium alloys or tungsten alloys with a "matrix" based on iron, nickel or copper, having all of the following:
   a. A density exceeding 17.5 g/cm^3;
   b. An elastic limit exceeding 880 MPa;
   c. An ultimate tensile strength exceeding 1,270 MPa; and
   d. An elongation exceeding 8%.

1. C. 5. "Superconductive" "composite" conductors in lengths exceeding 100m or with a mass exceeding 100 g. as follows:
   a. Multifilamentary "superconductive" "composite" conductors containing one or more niobium-titanium filaments:
      1. Embedded in a "matrix" other than a copper or copper-based mixed "matrix"; or
      2. Having a cross-section area less than 0.28×10^{-4} mm^2 (6 μm in diameter for circular filaments);

Dual-Use List - Category 1 - ADVANCED MATERIALS

1. C. 5. b. "Superconductive" "composite" conductors consisting of one or more "superconductive" filaments other than niobium-titanium, having all of the following:
   1. A "critical temperature" at zero magnetic induction exceeding 9.85 K (-263.31°C) but less than 24 K (-249.16°C);
   2. A cross-section area less than 0.28×10^{-4} mm^2; and
   3. Remaining in the "superconductive" state at a temperature of 4.2 K (-268.96°C) when exposed to a magnetic field corresponding to a magnetic induction of 12 T.

1. C. 6. Fluids and lubricating materials, as follows:
   a. Hydraulic fluids containing, as their principal ingredients, any of the following compounds or materials:
      1. Synthetic silahydrocarbon oils, having all of the following:
         Technical Note
         For the purpose of 1.C.6.a.1., silahydrocarbon oils contain exclusively silicon, hydrogen and carbon.
         a. A flash point exceeding 477 K (204°C);
         b. A pour point at 239 K (-34°C) or less;
         c. A viscosity index of 75 or more; and
         d. A thermal stability at 616 K (343°C); or
      2. Chlorofluorocarbons, having all of the following:
         Technical Note
         For the purpose of 1.C.6.a.2., chlorofluorocarbons contain exclusively carbon, fluorine and chlorine.
         a. No flash point;
         b. An autogenous ignition temperature exceeding 977 K (704°C);
         c. A pour point at 219 K (-54°C) or less;
         d. A viscosity index of 80 or more; and
         e. A boiling point at 473 K (200°C) or higher;
   b. Lubricating materials containing, as their principal ingredients, any of the following compounds or materials:
      1. Phenylene or alkylphenylene ethers or thio-ethers, or their mixtures, containing more than two ether or thio-ether functions or mixtures thereof; or
      2. Fluorinated silicone fluids with a kinematic viscosity of less than 5,000 mm^2/s (5,000 centistokes) measured at 298 K (25°C);
   c. Damping or flotation fluids with a purity exceeding 99.8%, containing less than 25 particles of 200 µm or larger in size per 100 ml and made from at least 85% of any of the following compounds or materials:
      1. Dibromotetrafluoroethane;
      2. Polychlorotrifluoroethylene (oily and waxy modifications only); or
      3. Polybromotrifluoroethylene;

Dual-Use List - Category 1 - ADVANCED MATERIALS

1. C. 6. d. Fluorocarbon electronic cooling fluids, having all of the following characteristics:
   1. Containing 85% by weight or more of any of the following, or mixtures thereof:
      a. Monomeric forms of perfluoropolyalkylether-triazines or perfluoroaliphatic-ethers;
      b. Perfluoroalkylantines;
      c. Perfluorocycloalkanes; or
      d. Perfluoroalkanes;
   2. Density at 298 K (25°C) of 1.5 g/ml or more;
   3. In a liquid state at 273 K (0°C); and
   4. Containing 60% or more by weight of fluorine.

Technical Note

For the purpose of 1.C.6.:

a. Flash point is determined using the Cleveland Open Cup Method described in ASTM D-92 or national equivalents;

b. Pour point is determined using the method described in ASTM D-97 or national equivalents;

c. Viscosity index is determined using the method described in ASTM D-2270 or national equivalents;

d. Thermal stability is determined by the following test procedure or national equivalents:
Twenty ml of the fluid under test is placed in a 46 ml type 317 stainless steel chamber containing one each of 12.5 mm (nominal) diameter balls of M-10 tool steel, 52100 steel and naval bronze (60% Cu, 39% Zn, 0.75% Sn);
The chamber is purged with nitrogen, sealed at atmospheric pressure and the temperature raised to and maintained at 644 ± 6 K (371 ± 6°C) for six hours;
The specimen will be considered thermally stable if, on completion of the above procedure, all of the following conditions are met:
   1. The loss in weight of each ball is less than 10 mg/mm^2 of ball surface;
   2. The change in original viscosity as determined at 311 K (38°C) is less than 25%; and
   3. The total acid or base number is less than 0.40;

e. Autogenous ignition temperature is determined using the method described in ASTM E-659 or national equivalents.

Dual-Use List - Category 1 - ADVANCED MATERIALS

1. C. 7. Ceramic base materials, non-"composite" ceramic materials, ceramic-"matrix" "composite" materials and precursor materials, as follows:

a. Base materials of single or complex borides of titanium having total metallic impurities, excluding intentional additions, of less than 5,000ppm, an average particle size equal to or less than 5 μm and no more than 10% of the particles larger than 10 μm;

b. Non-"composite" ceramic materials in crude or semi-fabricated form, composed of borides of titanium with a density of 98% or more of the theoretical density;
Note *1.C.7.b. does not control abrasives.*

c. Ceramic-ceramic "composite" materials with a glass or oxide-"matrix" and reinforced with fibres having all of the following:
1. Made from any of the following materials:
a. Si-N;
b. Si-C;
c. Si-Al-O-N; or
d. Si-O-N; and
2. Having a specific tensile strength exceeding 12.7 x 10^3m;

d. Ceramic-ceramic "composite" materials, with or without a continuous metallic phase, incorporating particles, whiskers or fibres, where carbides or nitrides of silicon, zirconium or boron form the "matrix";

e. Precursor materials (i.e., special purpose polymeric or metallo-organic materials) for producing any phase or phases of the materials controlled by 1.C.7.e., as follows:
1. Polydiorganosilanes (for producing silicon carbide);
2. Polysilazanes (for producing silicon nitride);
3. Polycarbosilazanes (for producing ceramics with silicon, carbon and nitrogen components);

f. Ceramic-ceramic "composite" materials with an oxide or glass "matrix" reinforced with continuous fibres from any of the following systems:
1. Al_2O_3; or
2. Si-C-N.
Note *1.C.7.f. does not control "composites" containing fibres from these systems with a fibre tensile strength of less than 700 MPa at 1,273 K (1,000°C) or fibre tensile creep resistance of more than 1% creep strain at 100 MPa load and 1,273 K (1,000°C) for 100 hours.*

Dual-Use List - Category 1 - ADVANCED MATERIALS

1. C. 8. Non-fluorinated polymeric substances, as follows:
   a. 1. Bismaleimides;
      2. Aromatic polyamide-imides;
      3. Aromatic polyimides;
      4. Aromatic polyetherimides having a glass transition temperature (Tg) exceeding 513 K (240°C) determined using the dry method described in ASTM D 3418;

      Note *1.C.8.a. does not control non-fusible compression moulding powders or moulded forms.*

   b. Thermoplastic liquid crystal copolymers having a heat distortion temperature exceeding 523 K (250°C) measured according to ASTM D-648, method A, or national equivalents, with a load of 1.82 N/mm^2 and composed of:
      1. Any of the following:
         a. Phenylene, biphenylene or naphthalene; or
         b. Methyl, tertiary-butyl or phenyl substituted phenylene, biphenylene or naphthalene; and
      2. Any of the following acids:
         a. Terephthalic acid;
         b. 6-hydroxy-2 naphthoic acid; or
         c. 4-hydroxybenzoic acid;

   c. Polyarylene ether ketones, as follows:
      1. Polyether ether ketone (PEEK);
      2. Polyether ketone ketone (PEKK);
      3. Polyether ketone (PEK);
      4. Polyether ketone ether ketone ketone (PEKEKK);

   d. Polyarylene ketones;

   e. Polyarylene sulphides, where the arylene group is biphenylene, triphenylene or combinations thereof;

   f. Polybiphenylenethersulphone.

   Technical Note
   The glass transition temperature (Tg) for 1.C.8. materials is determined using the method described in ASTM D 3418 using the dry method.

1. C. 9. Unprocessed fluorinated compounds, as follows:
   a. Copolymers of vinylidene fluoride having 75% or more beta crystalline structure without stretching;
   b. Fluorinated polyimides containing 10% by weight or more of combined fluorine;
   c. Fluorinated phosphazene elastomers containing 30% by weight or more of combined fluorine.

1. C. 10. "Fibrous or filamentary materials" which may be used in organic "matrix", metallic "matrix" or carbon "matrix" "composite" structures or laminates, as follows:
   a. Organic "fibrous or filamentary materials", having all of the following:
      1. A specific modulus exceeding 12.7 x 10^6 m; and

Dual-Use List - Category 1 - ADVANCED MATERIALS

2. A specific tensile strength exceeding 23.5×10^4 m;

Note *1.C.10.a. does not control polyethylene.*

b. Carbon "fibrous or filamentary materials", having all of the following:
   1. A specific modulus exceeding 12.7×10^6 m; and
   2. A specific tensile strength exceeding 23.5×10^4 m;

Technical Note
Properties for materials described in 1.C.10.b. should be determined using SACMA recommended methods SRM 12 to 17, or national equivalent tow tests, such as Japanese Industrial Standard JIS-R-7601, Paragraph 6.6.2., and based on lot average.

Note *1.C.10.b. does not control fabric made from "fibrous or filamentary materials" for the repair of aircraft structures or laminates, in which the size of individual sheets does not exceed 50 cm x 90 cm.*

c. Inorganic "fibrous or filamentary materials", having all of the following:
   1. A specific modulus exceeding 2.54×10^6 m; and
   2. A melting, softening, decomposition or sublimation point exceeding 1,922 K (1,649°C) in an inert environment;

Note *1.C.10. c. does not control:*
   1. *Discontinuous, multiphase, polycrystalline alumina fibres in chopped fibre or random mat form, containing 3 weight percent or more silica, with a specific modulus of less than 10×10^6 m;*
   2. *Molybdenum and molybdenum alloy fibres;*
   3. *Boron fibres;*
   4. *Discontinuous ceramic fibres with a melting, softening, decomposition or sublimation point lower than 2,043 K (1,770°C) in an inert environment.*

d. "Fibrous or filamentary materials":
   1. Composed of any of the following:
      a. Polyetherimides controlled by 1.C.8.a.; or
      b. Materials controlled by 1.C.8.b. to 1.C.8.f.; or
   2. Composed of materials controlled by 1.C.10.d.1.a. or 1.C.10.d.1.b. and "commingled" with other fibres controlled by 1.C.10.a., 1.C.10.b. or 1.C.10.c.;

Dual-Use List - Category 1 - ADVANCED MATERIALS

1. C. 10. e. Resin-impregnated or pitch-impregnated fibres (prepregs), metal or carbon-coated fibres (preforms) or "carbon fibre preforms", as follows:
   1. Made from "fibrous or filamentary materials" controlled by 1.C.10.a., 1.C.10.b. or 1.C.10.c.;
   2. Made from organic or carbon "fibrous or filamentary materials":
      a. With a specific tensile strength exceeding 17.7 x 10^4 m;
      b. With a specific modulus exceeding 10.15 x 10^6 m;
      c. Not controlled by 1.C.10.a. or 1.C.10.b.; and
      d. When impregnated with materials controlled by 1.C.8. or 1.C.9.b., having a glass transition temperature (Tg) exceeding 383 K (110°C) or with phenolic or epoxy resins, having a glass transition temperature (Tg) equal to or exceeding 418 K (145°C).

Notes *1.C.10.e. does not control:*
   1. *Epoxy resin "matrix" impregnated carbon "fibrous or filamentary materials" (prepregs) for the repair of aircraft structures or laminates, in which the size of individual sheets of prepreg does not exceed 50 cm x 90 cm;*
   2. *Prepregs when impregnated with phenolic or epoxy resins having a glass transition temperature (Tg) less than 433K (160°C) and a cure temperature lower than the glass transition temperature.*

Technical Note
The glass transition temperature (Tg) for 1.C.10.e. materials is determined using the method described in ASTM D 3418 using the dry method. The glass transition temperature for phenolic and epoxy resins is determined using the method described in ASTM D 4065 at a frequency of 1Hz and a heating rate of 2 K (°C) per minute using the dry method.

Technical Notes
1. *Specific modulus: Young's modulus in pascals, equivalent to N/m^2 divided by specific weight in N/m^3, measured at a temperature of (296 ± 2) K ((23 ± 2)°C) and a relative humidity of (50 ± 5)%.*
2. *Specific tensile strength: ultimate tensile strength in pascals, equivalent to N/m^2 divided by specific weight in N/m^3, measured at a temperature of (296 ± 2) K ((23 ± 2)°C) and a relative humidity of (50 ± 5)%.*

1. C. 11. Metals and compounds, as follows:
   a. Metals in particle sizes of less than 60 µm whether spherical, atomised, spheroidal, flaked or ground, manufactured from material consisting of 99% or more of zirconium, magnesium and alloys of these;
   Technical Note
   The natural content of hafnium in the zirconium (typically 2% to 7%) is counted with the zirconium.

Note *The metals or alloys listed in 1.C.11.a. are controlled whether or not the metals or alloys are encapsulated in aluminium, magnesium, zirconium or beryllium.*

Dual-Use List - Category 1 - ADVANCED MATERIALS

1. C. 11. b. Boron or boron carbide of 85% purity or higher and a particle size of 60 µm or less;
Note *The metals or alloys listed in 1.C.11.b. are controlled whether or not the metals or alloys are encapsulated in aluminium, magnesium, zirconium or beryllium.*

c. Guanidine nitrate;

d. Nitroguanidine (NQ) (CAS 556-88-7).

1. C. 12. Materials as follows:
Technical Note
These materials are typically used for nuclear heat sources.

a. Plutonium in any form with a plutonium isotopic assay of plutonium-238 of more than 50% by weight;
Note *1.C.12.a. does not control:*
1. Shipments with a plutonium content of 1 g or less;
2. Shipments of 3 "effective grams" or less when contained in a sensing component in instruments.

b. "Previously separated" neptunium-237 in any form.
Note *1.C.12.b. does not control shipments with a neptunium-237 content of 1 g or less.*

1. D. SOFTWARE

1. D. 1. "Software" specially designed or modified for the "development", "production" or "use" of equipment controlled by 1.B.

1. D. 2. "Software" for the "development" of organic "matrix", metal "matrix" or carbon "matrix" laminates or "composites".

1. E. TECHNOLOGY

1. E. 1. "Technology" according to the General Technology Note for the "development" or "production" of equipment or materials controlled by 1.A.1.b., 1.A.1.c., 1.A.2. to 1.A.5., 1.B. or 1.C.

1. E. 2. Other "technology", as follows:
a. "Technology" for the "development" or "production" of polybenzothiazoles or polybenzoxazoles;

b. "Technology" for the "development" or "production" of fluoroelastomer compounds containing at least one vinylether monomer;

1. E. 2. c. "Technology" for the design or "production" of the following base materials or non-"composite" ceramic materials:
1. Base materials having all of the following characteristics:
a. Any of the following compositions:

Dual-Use List - Category 1 - ADVANCED MATERIALS

1. Single or complex oxides of zirconium and complex oxides of silicon or aluminium;
2. Single nitrides of boron (cubic crystalline forms);
3. Single or complex carbides of silicon or boron; or
4. Single or complex nitrides of silicon;

b. Total metallic impurities, excluding intentional additions, of less than:
1. 1,000 ppm for single oxides or carbides; or
2. 5,000 ppm for complex compound or single nitrides; and

c. Being any of the following:
1. Zirconia with an average particle size equal to or less than 1 μm and no more than 10% of the particles larger than 5 μm;
2. Other base materials with an average particle size equal to or less than 5 μm and no more than 10% of the particles larger than 10 μm; or
3. Having all of the following:
a. Platelets with a length to thickness ratio exceeding 5;
b. Whiskers with a length to diameter ratio exceeding 10 for diameters less than 2 μm; and
c. Continuous or chopped fibres less than 10 μm in diameter;

2. Non-"composite" ceramic materials composed of the materials described in 1.E.2.c.1.;
Note *1.E.2.c.2. does not control technology for the design or production of abrasives.*

1. E. 2. d. "Technology" for the "production" of aromatic polyamide fibres;

e. "Technology" for the installation, maintenance or repair of materials controlled by 1.C.1;

f. "Technology" for the repair of "composite" structures, laminates or materials controlled by 1.A.2., 1.C.7.c. or 1.C.7.d.
Note *1.E.2.f. does not control "technology" for the repair of "civil aircraft" structures using carbon "fibrous or filamentary materials" and epoxy resins, contained in aircraft manufacturers' manuals.*

Dual-Use List - Category 2 - MATERIALS PROCESSING

2. A. SYSTEMS, EQUIPMENT AND COMPONENTS

2. A. 1. Anti-friction bearings and bearing systems, as follows, and components therefor:

Note *2.A.1. does not control balls with tolerances specified by the manufacturer in accordance with ISO 3290 as grade 5 or worse.*

a. Ball bearings and solid roller bearings having tolerances specified by the manufacturer in accordance with ISO 492 Tolerance Class 4 (or ANSI/ABMA Std 20 Tolerance Class ABEC-7 or RBEC-7, or other national equivalents), or better, and having rings, balls or rollers made from monel or beryllium;
Note *2.A.1.a. does not control tapered roller bearings.*

b. Other ball bearings and solid roller bearings having tolerances specified by the manufacturer in accordance with ISO 492 Tolerance Class 2 (or ANSI/ABMA Std 20 Tolerance Class ABEC-9 or RBEC-9, or other national equivalents), or better;
Note *2.A.1.b. does not control tapered roller bearings.*

c. Active magnetic bearing systems using any of the following:
1. Materials with flux densities of 2.0 T or greater and yield strengths greater than 414 MPa;
2. All-electromagnetic 3D homopolar bias designs for actuators; or
3. High temperature (450 K (177°C) and above) position sensors.

2. B. TEST, INSPECTION AND PRODUCTION EQUIPMENT

Technical Notes

1. *Secondary parallel contouring axes, (e.g., the w-axis on horizontal boring mills or a secondary rotary axis the centre line of which is parallel to the primary rotary axis) are not counted in the total number of contouring axes. Rotary axes need not rotate over 360°. A rotary axis can be driven by a linear device (e.g., a screw or a rack-and-pinion).*
2. *For the purposes of 2.B., the number of axes which can be coordinated simultaneously for "contouring control" is the number of axes which affect relative movement between any one workpiece and a tool, cutting head or grinding wheel which is cutting or removing material from the workpiece. This does not include any additional axes which affect other relative movement within the machine. Such axes include:*
   a. *Wheel-dressing systems in grinding machines;*
   b. *Parallel rotary axes designed for mounting of separate workpieces;*
   c. *Co-linear rotary axes designed for manipulating the same workpiece by holding it in a chuck from different ends.*
3. *Axis nomenclature shall be in accordance with International Standard ISO 841, 'Numerical Control Machines - Axis and Motion Nomenclature'.*
4. *For the purposes of this Category a "tilting spindle" is counted as a rotary axis.*
5. *Stated positioning accuracy levels derived from measurements made according to ISO 230/2 (1997) or national equivalents may be used for each machine tool model instead of individual machine tests. Stated positioning accuracy means the accuracy value provided to national licensing authorities as representative of the accuracy of a machine model.*

Dual-Use List - Category 2 - MATERIALS PROCESSING

Determination of Stated Values

a. Select five machines of a model to be evaluated;

b. Measure the linear axis accuracies according to ISO 230/2 (1997);

c. Determine the A-values for each axis of each machine. The method of calculating the A-value is described in the ISO standard;

d. Determine the mean value of the A-value of each axis. This mean value $\bar{A}$ becomes the stated value of each axis for the model ($\bar{A}x$ $\bar{A}y$ ...);

e. Since the Category 2 list refers to each linear axis there will be as many stated values as there are linear axes;

f. If any axis of a machine model not controlled by 2.B.1.a. to 2.B.1.c. has a stated accuracy $\bar{A}$ of 5 microns for grinding machines and 6.5 microns for milling and turning machines or better, the builder should be required to reaffirm the accuracy level once every eighteen months.

2. B. 1. [Deleted]

2. B. 1. b. [Deleted]

2. B. 1. c. [Deleted]

2. B. 1. d. [Deleted]

2. B. 1. e. [Deleted]

2. B. 1. f. Deep-hole-drilling machines and turning machines modified for deep-hole-drilling, having a maximum depth-of-bore capability exceeding 5,000 mm and specially designed components therefor.

2. B. 2. Deleted.

2. B. 3. "Numerically controlled" or manual machine tools, and specially designed components, controls and accessories therefor, specially designed for the shaving, finishing, grinding or honing of hardened (R_c = 40 or more) spur, helical and double-helical gears with a pitch diameter exceeding 1,250 mm and a face width of 15% of pitch diameter or larger finished to a quality of AGMA 14 or better (equivalent to ISO 1328 class 3).

2. B. 4. Hot "isostatic presses", having all of the following, and specially designed components and accessories therefor:

a. A controlled thermal environment within the closed cavity and a chamber cavity with an inside diameter of 406 mm or more; and

b. Any of the following:

1. A maximum working pressure exceeding 207 MPa;

2. A controlled thermal environment exceeding 1,773 K (1,500° C); or

3. A facility for hydrocarbon impregnation and removal of resultant gaseous degradation products.

Technical Note

The inside chamber dimension is that of the chamber in which both the working temperature and the working pressure are achieved and does not include fixtures. That dimension will be the smaller of either the inside diameter of the pressure chamber or the inside diameter of the insulated furnace chamber, depending on which of the two chambers is located inside the other.

Dual-Use List - Category 2 - MATERIALS PROCESSING

2. B. 5. Equipment specially designed for the deposition, processing and in-process control of inorganic overlays, coatings and surface modifications, as follows, for non-electronic substrates, by processes shown in the Table and associated Notes following 2.E.3.f., and specially designed automated handling, positioning, manipulation and control components therefor:

a. "Stored programme controlled" chemical vapour deposition (CVD) production equipment having all of the following:
   1. Process modified for one of the following:
      a. Pulsating CVD;
      b. Controlled nucleation thermal deposition (CNTD); or
      c. Plasma enhanced or plasma assisted CVD; and
   2. Any of the following:
      a. Incorporating high vacuum (equal to or less than 0.01 Pa) rotating seals; or
      b. Incorporating *in situ* coating thickness control;

b. "Stored programme controlled" ion implantation production equipment having beam currents of 5 mA or more;

c. "Stored programme controlled" electron beam physical vapour deposition (EB-PVD) production equipment incorporating power systems rated for over 80 kW, having any of the following:
   1. A liquid pool level "laser" control system which regulates precisely the ingots feed rate; or
   2. A computer controlled rate monitor operating on the principle of photo-luminescence of the ionised atoms in the evaporant stream to control the deposition rate of a coating containing two or more elements;

d. "Stored programme controlled" plasma spraying production equipment having any of the following characteristics:
   1. Operating at reduced pressure controlled atmosphere (equal to or less than 10 kPa measured above and within 300 mm of the gun nozzle exit) in a vacuum chamber capable of evacuation down to 0.01 Pa prior to the spraying process; or
   2. Incorporating *in situ* coating thickness control;

e. "Stored programme controlled" sputter deposition production equipment capable of current densities of 0.1 mA/mm^2 or higher at a deposition rate of 15 µm/h or more;

f. "Stored programme controlled" cathodic arc deposition production equipment incorporating a grid of electromagnets for steering control of the arc spot on the cathode;

2. B. 5. g. "Stored programme controlled" ion plating production equipment allowing for the *in situ* measurement of any of the following:
   1. Coating thickness on the substrate and rate control; or
   2. Optical characteristics.

Note *2.B.5.a., 2.B.5.b, 2.B.5.e., 2.B.5.f. and 2.B.5.g. do not control chemical vapour deposition, cathodic arc, sputter deposition, ion plating or ion implantation equipment specially designed for cutting or machining tools.*

Dual-Use List - Category 2 - MATERIALS PROCESSING

2. B. 6. Dimensional inspection or measuring systems and equipment, as follows:

a. Computer controlled, "numerically controlled" or "stored programme controlled" dimensional inspection machines, having a three dimensional length (volumetric) "measurement uncertainty" equal to or less (better) than (1.7 + L/1,000) µm (L is the measured length in mm) tested according to ISO 10360-2;

2. B. 6. b. 1. and 2. [Deleted]

2. B. 6. c. Equipment for measuring surface irregularities, by measuring optical scatter as a function of angle, with a sensitivity of 0.5 nm or less (better).

Note 1 *Machine tools which can be used as measuring machines are controlled if they meet or exceed the criteria specified for the machine tool function or the measuring machine function.*

Note 2 *A machine described in 2.B.6. is controlled if it exceeds the control threshold anywhere within its operating range.*

2. B. 7. "Robots" having any of the following characteristics and specially designed controllers and "end-effectors" therefor:

a. Capable in real time of full three-dimensional image processing or full three-dimensional scene analysis to generate or modify "programmes" or to generate or modify numerical programme data;
Technical Note
The scene analysis limitation does not include approximation of the third dimension by viewing at a given angle, or limited grey scale interpretation for the perception of depth or texture for the approved tasks (2 1/2 D).

b. Specially designed to comply with national safety standards applicable to explosive munitions environments;

c. Specially designed or rated as radiation-hardened to withstand greater than 5×10^3 Gy (Si) without operational degradation; or

d. Specially designed to operate at altitudes exceeding 30,000 m.

2. B. 8. Assemblies or units, specially designed for machine tools, or dimensional inspection or measuring systems and equipment, as follows:

a. Linear position feedback units (e.g., inductive type devices, graduated scales, infrared systems or "laser" systems) having an overall "accuracy" less (better) than $(800 + (600 \times L \times 10^{-3}))$ nm (L equals the effective length in mm);
N.B. For "laser" systems see also Note to 2.B.6.b.1.

b. Rotary position feedback units (e.g., inductive type devices, graduated scales, infrared systems or "laser" systems) having an "accuracy" less (better) than 0.00025°;

N.B. For "laser" systems see also Note to 2.B.6.b.1.

c. "Compound rotary tables" and "tilting spindles", capable of upgrading, according to the manufacturer's specifications, machine tools to or above the levels specified in 2.B.

Dual-Use List - Category 2 - MATERIALS PROCESSING

2. B. 9. Spin-forming machines and flow-forming machines, which, according to the manufacturer's technical specification, can be equipped with "numerical control" units or a computer control and having all of the following:

a. Two or more controlled axes of which at least two can be coordinated simultaneously for "contouring control"; and

b. A roller force more than 60 kN.

Technical Note

Machines combining the function of spin-forming and flow-forming are for the purpose of 2.B.9. regarded as flow-forming machines.

2. C. MATERIALS - None

2. D. SOFTWARE

1. "Software", other than that controlled by 2.D.2, specially designed or modified for the "development", "production" or "use" of equipment controlled by 2.A. or 2.B.

2. "Software" for electronic devices, even when residing in an electronic device or system, enabling such devices or systems to function as a "numerical control" unit, capable of coordinating simultaneously more than 4 axes for "contouring control".

Note 2.D.2. does not control "software" specially designed or modified for the operation of machine tools not controlled by Category 2.

2. E. TECHNOLOGY

2. E. 1. "Technology" according to the General Technology Note for the "development" of equipment or "software" controlled by 2.A., 2.B. or 2.D.

2. E. 2. "Technology" according to the General Technology Note for the "production" of equipment controlled by 2.A. or 2.B.

2. E. 3. Other "technology", as follows:

a. "Technology" for the "development" of interactive graphics as an integrated part in "numerical control" units for preparation or modification of part programmes;

b. "Technology" for metal-working manufacturing processes, as follows:

1. "Technology" for the design of tools, dies or fixtures specially designed for any of the following processes:

a. "Superplastic forming";

b. "Diffusion bonding"; or

c. "Direct-acting hydraulic pressing";

Dual-Use List - Category 2 - MATERIALS PROCESSING

2. E. 3. b. 2. Technical data consisting of process methods or parameters as listed below used to control:

a. "Superplastic forming" of aluminium alloys, titanium alloys or "superalloys":
   1. Surface preparation;
   2. Strain rate;
   3. Temperature;
   4. Pressure;

b. "Diffusion bonding" of "superalloys" or titanium alloys:
   1. Surface preparation;
   2. Temperature;
   3. Pressure;

c. "Direct-acting hydraulic pressing" of aluminium alloys or titanium alloys:
   1. Pressure;
   2. Cycle time;

d. "Hot isostatic densification" of titanium alloys, aluminium alloys or "superalloys":
   1. Temperature;
   2. Pressure;
   3. Cycle time;

2. E 3. c. "Technology" for the "development" or "production" of hydraulic stretch-forming machines and dies therefor, for the manufacture of airframe structures;

d. "Technology" for the "development" of generators of machine tool instructions (e.g., part programmes) from design data residing inside "numerical control" units;

e. "Technology" for the "development" of integration "software" for incorporation of expert systems for advanced decision support of shop floor operations into "numerical control" units;

f. "Technology" for the application of inorganic overlay coatings or inorganic surface modification coatings (specified in column 3 of the following table) to non-electronic substrates (specified in column 2 of the following table), by processes specified in column 1 of the following table and defined in the Technical Note.

N.B. This Table should be read to control the technology of a particular 'Coating Process' only when the 'Resultant Coating' in column 3 is in a paragraph directly across from the relevant 'Substrate' under column 2. For example, Chemical Vapour Deposition (CVD) coating process technical data are controlled for the application of 'silicides' to 'Carbon-carbon, Ceramic and Metal "matrix" "composites"' substrates, but are not controlled for the application of 'silicides' to 'Cemented tungsten carbide (16), Silicon carbide (18)' substrates. In the second case, the 'Resultant Coating' is not listed in the paragraph under column 3 directly across from the paragraph under column 2 listing 'Cemented tungsten carbide (16), Silicon carbide (18)'.

Dual-Use List - Category 2 - MATERIALS PROCESSING

TABLE - DEPOSITION TECHNIQUES

1. Coating Process (1)*	2. Substrate	3. Resultant Coating
A. Chemical Vapour Deposition (CVD)	"Superalloys"	Aluminides for internal passages
	Ceramics (19) and Low-expansion glasses (14)	Silicides Carbides Dielectric layers (15) Diamond Diamond-like carbon (17)
	Carbon-carbon, Ceramic and Metal "matrix" "composites"	Silicides Carbides Refractory metals Mixtures thereof (4) Dielectric layers (15) Aluminides Alloyed aluminides (2) Boron nitride
	Cemented tungsten carbide (16), Silicon carbide (18)	Carbides Tungsten Mixtures thereof (4) Dielectric layers (15)
	Molybdenum and Molybdenum alloys	Dielectric layers (15)
	Beryllium and Beryllium alloys	Dielectric layers (15) Diamond Diamond-like carbon (17)
	Sensor window materials (9)	Dielectric layers (15) Diamond Diamond-like carbon (17)

Dual-Use List - Category 2 - MATERIALS PROCESSING

TABLE - DEPOSITION TECHNIQUES

1. Coating Process (1)	2. Substrate	3. Resultant Coating
B. Thermal-Evaporation Physical Vapour Deposition (TE-PVD)		
B.1. Physical Vapour Deposition (PVD): Electron-Beam (EB-PVD)	"Superalloys"	Alloyed silicides Alloyed aluminides (2) MCrA1X (5) Modified zirconia (12) Silicides Aluminides Mixtures thereof (4)
	Ceramics (19) and Low-expansion glasses (14)	Dielectric layers (15)
	Corrosion resistant steel (7)	MCrA1X (5) Modified zirconia (12) Mixtures thereof (4)
	Carbon-carbon, Ceramic and Metal "matrix" "composites"	Silicides Carbides Refractory metals Mixtures thereof (4) Dielectric layers (15) Boron nitride
	Cemented tungsten carbide (16), Silicon carbide (18)	Carbides Tungsten Mixtures thereof (4) Dielectric layers (15)
	Molybdenum and Molybdenum alloys	Dielectric layers (15)
	Beryllium and Beryllium alloys	Dielectric layers (15) Borides Beryllium
	Sensor window materials (9)	Dielectric layers (15)
	Titanium alloys (13)	Borides Nitrides

Dual-Use List - Category 2 - MATERIALS PROCESSING

TABLE - DEPOSITION TECHNIQUES

1. Coating Process (1)	2. Substrate	3. Resultant Coating
B.2. Ion assisted resistive heating Physical Vapour Deposition (PVD) (Ion Plating)	Ceramics (19) and Low-expansion glasses (14)	Dielectric layers (15) Diamond-like carbon (17)
	Carbon-carbon, Ceramic and Metal "matrix" "composites"	Dielectric layers (15)
	Cemented tungsten carbide (16), Silicon carbide	Dielectric layers (15)
	Molybdenum and Molybdenum alloys	Dielectric layers (15)
	Beryllium and Beryllium alloys	Dielectric layers (15)
	Sensor window materials (9)	Dielectric layers (15) Diamond-like carbon (17)
B.3 Physical Vapour Deposition (PVD): "Laser" Vaporization	Ceramics (19) and Low-expansion glasses (14)	Silicides Dielectric layers (15) Diamond-like carbon (17)
	Carbon-carbon Ceramic and Metal "matrix" "composites"	Dielectric layers (15)
	Cemented tungsten carbide (16), Silicon carbide	Dielectric layers (15)
	Molybdenum and Molybdenum alloys	Dielectric layers (15)
	Beryllium and Beryllium alloys	Dielectric layers (15)
	Sensor window materials (9)	Dielectric layers (15) Diamond-like carbon
B.4. Physical Vapour Deposition (PVD): Cathodic Arc Discharge	"Superalloys"	Alloyed silicides Alloyed aluminides (2) MCrAlX (5)
	Polymers (11) and Organic "matrix" "composites"	Borides Carbides Nitrides Diamond-like carbon (17)

Dual-Use List - Category 2 - MATERIALS PROCESSING

TABLE - DEPOSITION TECHNIQUES

1. Coating Process (1)	2. Substrate	3. Resultant Coating
C. Pack cementation (see A above for out-of-pack cementation) (10)	Carbon-carbon, Ceramic and Metal "matrix" "composites"	Silicides Carbides Mixtures thereof (4)
	Titanium alloys (13)	Silicides Aluminides Alloyed aluminides (2)
	Refractory metals and alloys (8)	Silicides Oxides
D. Plasma spraying	"Superalloys"	MCrA1X (5) Modified zirconia (12) Mixtures thereof (4) Abradable Nickel-Graphite Abradable materials containing Ni-Cr-Al Abradable Al-Si-Polyester Alloyed aluminides (2)
	Aluminium alloys (6)	MCrA1X (5) Modified zirconia (12) Silicides Mixtures thereof (4)
	Refractory metals and alloys (8)	Aluminides Silicides Carbides
	Corrosion resistant steel (7)	MCrA1X (5) Modified zirconia (12) Mixtures thereof (4)
	Titanium alloys (13)	Carbides Aluminides Silicides Alloyed aluminides (2) Abradable Nickel-Graphite Abradable materials containing Ni-Cr-Al Abradable Al-Si-Polyester
E. Slurry Deposition	Refractory metals and alloys (8)	Fused silicides Fused aluminides except for resistance heating elements
	Carbon-carbon Ceramic and Metal "matrix" "composites"	Silicides Carbides Mixtures thereof (4)

Dual-Use List - Category 2 - MATERIALS PROCESSING

TABLE - DEPOSITION TECHNIQUES

1. Coating Process (1)	2. Substrate	3. Resultant Coating
F. Sputter Deposition	"Superalloys"	Alloyed silicides Alloyed aluminides (2) Noble metal modified aluminides (3) MCrA1X (5) Modified zirconia (12) Platinum Mixtures thereof (4)
	Ceramics and Low-expansion glasses (14)	Silicides Platinum Mixtures thereof (4) Dielectric layers (15) Diamond-like carbon (17)
	Titanium alloys (13)	Borides Nitrides Oxides Silicides Aluminides Alloyed aluminides (2) Carbides
	Carbon-carbon Ceramic and Metal "matrix" "composites"	Silicides Carbides Refractory metals Mixtures thereof (4) Dielectric layers (15) Boron nitride
	Cemented tungsten carbide (16), Silicon carbide (18)	Carbides Tungsten Mixtures thereof (4) Dielectric layers (15) Boron nitride
	Molybdenum and Molybdenum alloys	Dielectric layers (15)
	Beryllium and Beryllium alloys	Borides Dielectric layers (15) Beryllium
	Sensor window materials (9)	Dielectric layers (15) Diamond-like carbon (17)
	Refractory metals and alloys (8)	Aluminides Silicides Oxides Carbides

Dual-Use List - Category 2 - MATERIALS PROCESSING

TABLE - DEPOSITION TECHNIQUES

1. Coating Process (1)	2. Substrate	3. Resultant Coating
G. Ion Implantation	High temperature bearing steels	Additions of Chromium Tantalum or Niobium (Columbium)
	Titanium alloys (13)	Borides Nitrides
	Beryllium and Beryllium alloys	Borides
	Cemented tungsten carbide (16)	Carbides Nitrides

Dual-Use List - Category 2 - MATERIALS PROCESSING

TABLE - DEPOSITION TECHNIQUES - NOTES

1. The term 'coating process' includes coating repair and refurbishing as well as original coating.

2. The term 'alloyed aluminide coating' includes single or multiple-step coatings in which an element or elements are deposited prior to or during application of the aluminide coating, even if these elements are deposited by another coating process. It does not, however, include the multiple use of single-step pack cementation processes to achieve alloyed aluminides.

3. The term 'noble metal modified aluminide' coating includes multiple-step coatings in which the noble metal or noble metals are laid down by some other coating process prior to application of the aluminide coating.

4. The term 'mixtures thereof' includes infiltrated material, graded compositions, co-deposits and multilayer deposits and are obtained by one or more of the coating processes specified in the Table.

5. 'MCrAlX' refers to a coating alloy where M equals cobalt, iron, nickel or combinations thereof and X equals hafnium, yttrium, silicon, tantalum in any amount or other intentional additions over 0.01 weight percent in various proportions and combinations, except:
   a. CoCrAlY coatings which contain less than 22 weight percent of chromium, less than 7 weight percent of aluminium and less than 2 weight percent of yttrium;
   b. CoCrAlY coatings which contain 22 to 24 weight percent of chromium, 10 to 12 weight percent of aluminium and 0.5 to 0.7 weight percent of yttrium; or
   c. NiCrAlY coatings which contain 21 to 23 weight percent of chromium, 10 to 12 weight percent of aluminium and 0.9 to 1.1 weight percent of yttrium.

6. The term 'aluminium alloys' refers to alloys having an ultimate tensile strength of 190 MPa or more measured at 293 K (20°C).

7. The term 'corrosion resistant steel' refers to AISI (American Iron and Steel Institute) 300 series or equivalent national standard steels.

8. 'Refractory metals and alloys' include the following metals and their alloys: niobium (columbium), molybdenum, tungsten and tantalum.

9. 'Sensor window materials', as follows: alumina, silicon, germanium, zinc sulphide, zinc selenide, gallium arsenide, diamond, gallium phosphide, sapphire and the following metal halides: sensor window materials of more than 40 mm diameter for zirconium fluoride and hafnium fluoride.

10. "Technology" for single-step pack cementation of solid airfoils is not controlled by Category 2.

11. 'Polymers', as follows: polyimide, polyester, polysulphide, polycarbonates and polyurethanes.

12. 'Modified zirconia' refers to additions of other metal oxides (e.g., calcia, magnesia, yttria, hafnia, rare earth oxides) to zirconia in order to stabilise certain crystallographic phases and phase compositions. Thermal barrier coatings made of zirconia, modified with calcia or magnesia by mixing or fusion, are not controlled.

13. 'Titanium alloys' refers only to aerospace alloys having an ultimate tensile strength of 900 MPa or more measured at 293 K (20°C).

Dual-Use List - Category 2 - MATERIALS PROCESSING

TABLE - DEPOSITION TECHNIQUES - NOTES

14. 'Low-expansion glasses' refers to glasses which have a coefficient of thermal expansion of 1 x 10^{-7} K^{-1} or less measured at 293 K (20°C).

15. 'Dielectric layers' are coatings constructed of multi-layers of insulator materials in which the interference properties of a design composed of materials of various refractive indices are used to reflect, transmit or absorb various wavelength bands. Dielectric layers refers to more than four dielectric layers or dielectric/metal "composite" layers.

16. 'Cemented tungsten carbide' does not include cutting and forming tool materials consisting of tungsten carbide/(cobalt, nickel), titanium carbide/(cobalt, nickel), chromium carbide/nickel-chromium and chromium carbide/nickel.

17. "Technology" specially designed to deposit diamond-like carbon on any of the following is not controlled: magnetic disk drives and heads, equipment for the manufacture of disposables, valves for faucets, acoustic diaphragms for speakers, engine parts for automobiles, cutting tools, punching-pressing dies, office automation equipment, microphones or medical devices.

18. 'Silicon carbide' does not include cutting and forming tool materials.

19. Ceramic substrates, as used in this entry, does not include ceramic materials containing 5% by weight, or greater, clay or cement content, either as separate constituents or in combination.

Dual-Use List - Category 2 - MATERIALS PROCESSING

TABLE - DEPOSITION TECHNIQUES - TECHNICAL NOTE

Processes specified in Column 1 of the Table are defined as follows:

a. Chemical Vapour Deposition (CVD) is an overlay coating or surface modification coating process wherein a metal, alloy, "composite", dielectric or ceramic is deposited upon a heated substrate. Gaseous reactants are decomposed or combined in the vicinity of a substrate resulting in the deposition of the desired elemental, alloy or compound material on the substrate. Energy for this decomposition or chemical reaction process may be provided by the heat of the substrate, a glow discharge plasma, or "laser" irradiation.

N.B.1 CVD includes the following processes: directed gas flow out-of-pack deposition, pulsating CVD, controlled nucleation thermal deposition (CNTD), plasma enhanced or plasma assisted CVD processes.

N.B.2 Pack denotes a substrate immersed in a powder mixture.

N.B.3 The gaseous reactants used in the out-of-pack process are produced using the same basic reactions and parameters as the pack cementation process, except that the substrate to be coated is not in contact with the powder mixture.

b. Thermal Evaporation-Physical Vapour Deposition (TE-PVD) is an overlay coating process conducted in a vacuum with a pressure less than 0.1 Pa wherein a source of thermal energy is used to vaporize the coating material. This process results in the condensation, or deposition, of the evaporated species onto appropriately positioned substrates.

The addition of gases to the vacuum chamber during the coating process to synthesize compound coatings is an ordinary modification of the process.

The use of ion or electron beams, or plasma, to activate or assist the coating's deposition is also a common modification in this technique. The use of monitors to provide in-process measurement of optical characteristics and thickness of coatings can be a feature of these processes.

Specific TE-PVD processes are as follows:

1. Electron Beam PVD uses an electron beam to heat and evaporate the material which forms the coating;
2. Ion Assisted Resistive Heating PVD employs electrically resistive heating sources in combination with impinging ion beam(s) to produce a controlled and uniform flux of evaporated coating species;
3. "Laser" Vaporization uses either pulsed or continuous wave "laser" beams to vaporize the material which forms the coating;
4. Cathodic Arc Deposition employs a consumable cathode of the material which forms the coating and has an arc discharge established on the surface by a momentary contact of a ground trigger. Controlled motion of arcing erodes the cathode surface creating a highly ionized plasma. The anode can be either a cone attached to the periphery of the cathode, through an insulator, or the chamber. Substrate biasing is used for non line-of-sight deposition.
   N.B. This definition does not include random cathodic arc deposition with non-biased substrates.

Dual-Use List - Category 2 - MATERIALS PROCESSING

TABLE - DEPOSITION TECHNIQUES - TECHNICAL NOTE

Processes specified in Column 1 of the Table - continued:

5. Ion Plating is a special modification of a general TE-PVD process in which a plasma or an ion source is used to ionize the species to be deposited, and a negative bias is applied to the substrate in order to facilitate the extraction of the species from the plasma. The introduction of reactive species, evaporation of solids within the process chamber, and the use of monitors to provide in-process measurement of optical characteristics and thicknesses of coatings are ordinary modifications of the process.

c. Pack Cementation is a surface modification coating or overlay coating process wherein a substrate is immersed in a powder mixture (a pack), that consists of:
   1. The metallic powders that are to be deposited (usually aluminium, chromium, silicon or combinations thereof);
   2. An activator (normally a halide salt); and
   3. An inert powder, most frequently alumina.

   The substrate and powder mixture is contained within a retort which is heated to between 1,030 K (757°C) and 1,375 K (1,102°C) for sufficient time to deposit the coating.

d. Plasma Spraying is an overlay coating process wherein a gun (spray torch) which produces and controls a plasma accepts powder or wire coating materials, melts them and propels them towards a substrate, whereon an integrally bonded coating is formed. Plasma spraying constitutes either low pressure plasma spraying or high velocity plasma spraying.
   N.B.1 Low pressure means less than ambient atmospheric pressure.
   N.B.2 High velocity refers to nozzle-exit gas velocity exceeding 750 m/s calculated at 293 K (20°C) at 0.1 MPa.

e. Slurry Deposition is a surface modification coating or overlay coating process wherein a metallic or ceramic powder with an organic binder is suspended in a liquid and is applied to a substrate by either spraying, dipping or painting, subsequent air or oven drying, and heat treatment to obtain the desired coating.

f. Sputter Deposition is an overlay coating process based on a momentum transfer phenomenon, wherein positive ions are accelerated by an electric field towards the surface of a target (coating material). The kinetic energy of the impacting ions is sufficient to cause target surface atoms to be released and deposited on an appropriately positioned substrate.
   N.B.1 The Table refers only to triode, magnetron or reactive sputter deposition which is used to increase adhesion of the coating and rate of deposition and to radio frequency (RF) augmented sputter deposition used to permit vaporisation of non-metallic coating materials.
   N.B.2 Low-energy ion beams (less than 5 keV) can be used to activate the deposition.

g. Ion Implantation is a surface modification coating process in which the element to be alloyed is ionized, accelerated through a potential gradient and implanted into the surface region of the substrate. This includes processes in which ion implantation is performed simultaneously with electron beam physical vapour deposition or sputter deposition.

Dual-Use List - Category 2 - MATERIALS PROCESSING

TABLE - DEPOSITION TECHNIQUES - STATEMENT OF UNDERSTANDING

It is understood that the following technical information, accompanying the table of deposition techniques, is for use as appropriate.

1. "Technology" for pretreatments of the substrates listed in the Table, as follows:
   a. Chemical stripping and cleaning bath cycle parameters, as follows:
      1. Bath composition
         a. For the removal of old or defective coatings, corrosion product or foreign deposits;
         b. For preparation of virgin substrates;
      2. Time in bath;
      3. Temperature of bath;
      4. Number and sequences of wash cycles;
   b. Visual and macroscopic criteria for acceptance of the cleaned part;
   c. Heat treatment cycle parameters, as follows:
      1. Atmosphere parameters, as follows:
         a. Composition of the atmosphere;
         b. Pressure of the atmosphere;
      2. Temperature for heat treatment;
      3. Time of heat treatment;
   d. Substrate surface preparation parameters, as follows:
      1. Grit blasting parameters, as follows:
         a. Grit composition:
         b. Grit size and shape;
         c. Grit velocity;
      2. Time and sequence of cleaning cycle after grit blast;
      3. Surface finish parameters;
      4. Application of binders to promote adhesion;
   e. Masking technique parameters, as follows:
      1. Material of mask;
      2. Location of mask;

2. "Technology" for in situ quality assurance techniques for evaluation of the coating processes listed in the Table, as follows:
   a. Atmosphere parameters, as follows:
      1. Composition of the atmosphere;
      2. Pressure of the atmosphere;
   b. Time parameters;
   c. Temperature parameters;
   d. Thickness parameters;
   e. Index of refraction parameters;
   f. Control of composition;

3. "Technology" for post deposition treatments of the coated substrates listed in the Table, as follows:
   a. Shot peening parameters, as follows:
      1. Shot composition;
      2. Shot size;
      3. Shot velocity;

Dual-Use List - Category 2 - MATERIALS PROCESSING

TABLE - DEPOSITION TECHNIQUES - STATEMENT OF UNDERSTANDING

3. b. Post shot peening cleaning parameters;
   c. Heat treatment cycle parameters, as follows:
      1. Atmosphere parameters, as follows:
         a. Composition of the atmosphere;
         b. Pressure of the atmosphere;
      2. Time-temperature cycles;
   d. Post heat treatment visual and macroscopic criteria for acceptance of the coated substrates;

4. "Technology" for quality assurance techniques for the evaluation of the coated substrates listed in the Table, as follows:
   a. Statistical sampling criteria;
   b. Microscopic criteria for:
      1. Magnification;
      2. Coating thickness uniformity;
      3. Coating integrity;
      4. Coating composition;
      5. Coating and substrates bonding;
      6. Microstructural uniformity;
   c. Criteria for optical properties assessment (measured as a function of wavelength):
      1. Reflectance;
      2. Transmission;
      3. Absorption;
      4. Scatter;

5. "Technology" and parameters related to specific coating and surface modification processes listed in the Table, as follows:
   a. For Chemical Vapour Deposition (CVD):
      1. Coating source composition and formulation;
      2. Carrier gas composition;
      3. Substrate temperature;
      4. Time-temperature-pressure cycles;
      5. Gas control and part manipulation;

   b. For Thermal Evaporation - Physical Vapour Deposition (PVD):
      1. Ingot or coating material source composition;
      2. Substrate temperature;
      3. Reactive gas composition;
      4. Ingot feed rate or material vaporisation rate;
      5. Time-temperature-pressure cycles;
      6. Beam and part manipulation;
      7. "Laser" parameters, as follows:
         a. Wave length;
         b. Power density;
         c. Pulse length;
         d. Repetition ratio;
         e. Source;

Dual-Use List - Category 2 - MATERIALS PROCESSING

TABLE - DEPOSITION TECHNIQUES - STATEMENT OF UNDERSTANDING

5. c. For Pack Cementation:
   1. Pack composition and formulation;
   2. Carrier gas composition;
   3. Time-temperature-pressure cycles;

   d. For Plasma Spraying:
   1. Powder composition, preparation and size distributions;
   2. Feed gas composition and parameters;
   3. Substrate temperature;
   4. Gun power parameters;
   5. Spray distance;
   6. Spray angle;
   7. Cover gas composition, pressure and flow rates;
   8. Gun control and part manipulation;

   e. For Sputter Deposition:
   1. Target composition and fabrication;
   2. Geometrical positioning of part and target;
   3. Reactive gas composition;
   4. Electrical bias;
   5. Time-temperature-pressure cycles;
   6. Triode power;
   7. Part manipulation;

   f. For Ion Implantation:
   1. Beam control and part manipulation;
   2. Ion source design details;
   3. Control techniques for ion beam and deposition rate parameters;
   4. Time-temperature-pressure cycles;

   g. For Ion Plating:
   1. Beam control and part manipulation;
   2. Ion source design details;
   3. Control techniques for ion beam and deposition rate parameters;
   4. Time-temperature-pressure cycles;
   5. Coating material feed rate and vaporisation rate;
   6. Substrate temperature;
   7. Substrate bias parameters.

Dual-Use List - Category 3 - ELECTRONICS

3. A. SYSTEMS, EQUIPMENT AND COMPONENTS

Note 1 *The control status of equipment and components described in 3.A., other than those described in 3.A.1.a.3. to 3.A.1.a.10. or 3.A.1.a.12., which are specially designed for or which have the same functional characteristics as other equipment is determined by the control status of the other equipment.*

Note 2 *The control status of integrated circuits described in 3.A.1.a.3. to 3.A.1.a.9. or 3.A.1.a.12. which are unalterably programmed or designed for a specific function for another equipment is determined by the control status of the other equipment.*

N.B. When the manufacturer or applicant cannot determine the control status of the other equipment, the control status of the integrated circuits is determined in 3.A.1.a.3. to 3.A.1.a.9. and 3.A.1.a.12.

If the integrated circuit is a silicon-based "microcomputer microcircuit" or microcontroller microcircuit described in 3.A.1.a.3. having an operand (data) word length of 8 bit or less, the control status of the integrated circuit is determined in 3.A.1.a.3.

3. A. 1. Electronic components, as follows:

a. General purpose integrated circuits, as follows:

Note 1 *The control status of wafers (finished or unfinished), in which the function has been determined, is to be evaluated against the parameters of 3.A.1.a.*

Note 2 *Integrated circuits include the following types:*
"Monolithic integrated circuits";
"Hybrid integrated circuits";
"Multichip integrated circuits";
"Film type integrated circuits", including silicon-on-sapphire integrated circuits;
"Optical integrated circuits".

3. A. 1. a. 1. Integrated circuits, designed or rated as radiation hardened to withstand any of the following:
   a. A total dose of 5×10^3 Gy (Si) or higher; or
   b. A dose rate upset of 5×10^6 Gy (Si)/s or higher;

3. A. 1. a. 2. "Microprocessor microcircuits", "microcomputer microcircuits", microcontroller microcircuits, storage integrated circuits manufactured from a compound semiconductor, analogue-to-digital converters, digital-to-analogue converters, electro-optical or "optical integrated circuits" designed for "signal processing", field programmable logic devices, neural network integrated circuits, custom integrated-circuits for which either the function is unknown or the control status of the equipment in which the integrated circuit will be used is unknown, Fast Fourier Transform (FFT) processors, electrical erasable programmable read-only memories (EEPROMs), flash memories or static random-access memories (SRAMs), having any of the following:

a. Rated for operation at an ambient temperature above 398 K (+125°C);
b. Rated for operation at an ambient temperature below 218 K (-55°C); or
c. Rated for operation over the entire ambient temperature range from 218 K (-55°C) to 398 K (+125°C);

Note 3.A.1.a.2. does not apply to integrated circuits for civil automobile or railway train applications.

3. A. 1. a. 3. "Microprocessor microcircuits", "micro-computer microcircuits" and microcontroller microcircuits, having any of the following characteristics:

Note 3.A.1.a.3. includes digital signal processors, digital array processors and digital coprocessors.

a. A "composite theoretical performance" ("CTP") of 6,500 million theoretical operations per second (Mtops) or more and an arithmetic logic unit with an access width of 32 bit or more;
b. Manufactured from a compound semiconductor and operating at a clock frequency exceeding 40 MHz; or
c. More than one data or instruction bus or serial communication port that provides a direct external interconnection between parallel "microprocessor microcircuits" with a transfer rate exceeding 150 Mbyte/s;

3. A. 1. a. 4. Storage integrated circuits manufactured from a compound semiconductor;

3. A. 1. a. 5. Analogue-to-digital and digital-to-analogue converter integrated circuits, as follows:

a. Analogue-to-digital converters having any of the following:
   1. A resolution of 8 bit or more, but less than 12 bit, with a total conversion time of less than 5 ns;
   2. A resolution of 12 bit with a total conversion time of less than 200 ns; or
   3. A resolution of more than 12 bit with a total conversion time of less than 2 µs;
b. Digital-to-analogue converters with a resolution of 12 bit or more, and a "settling time" of less than 10 ns;

Technical Note

1. A resolution of n bit corresponds to a quantisation of 2^n levels.
2. Total conversion time is the inverse of the sample rate.

3. A. 1. a. 6. Electro-optical and "optical integrated circuits" designed for "signal processing" having all of the following:

a. One or more than one internal "laser" diode;
b. One or more than one internal light detecting element; and
c. Optical waveguides;

3. A. 1. a. 7. Field programmable logic devices having any of the following:

a. An equivalent usable gate count of more than 30,000 (2 input gates);
b. A typical "basic gate propagation delay time" of less than 0.4ns; or
c. A toggle frequency exceeding 133 MHz;

Dual-Use List - Category 3 - ELECTRONICS

Note 3.A.1.a.7. includes:

- *Simple Programmable Logic Devices (SPLDs)*
- *Complex Programmable Logic Devices (CPLDs)*
- *Field Programmable Gate Arrays (FPGAs)*
- *Field Programmable Logic Arrays (FPLAs)*
- *Field Programmable Interconnects (FPICs)*

N.B. Field programmable logic devices are also known as field programmable gate or field programmable logic arrays.

3. A. 1. a. 8. Deleted

3. A. 1. a. 9. Neural network integrated circuits;

3. A. 1. a. 10. Custom integrated circuits for which the function is unknown, or the control status of the equipment in which the integrated circuits will be used is unknown to the manufacturer, having any of the following:
   a. More than 1,000 terminals;
   b. A typical "basic gate propagation delay time" of less than 0.1 ns; or
   c. An operating frequency exceeding 3 GHz;

3. A. 1. a. 11. Digital integrated circuits, other than those described in 3.A.1.a.3 to 3.A.1.a.10. and 3.A.1.a.12., based upon any compound semiconductor and having any of the following:
   a. An equivalent gate count of more than 3,000 (2 input gates); or
   b. A toggle frequency exceeding 1.2 GHz;

3. A. 1. a. 12. Fast Fourier Transform (FFT) processors having a rated execution time for an N-point complex FFT of less than $(N \log_2 N)/20{,}480$ ms, where N is the number of points;
   Technical Note
   When N is equal to 1,024 points, the formula in 3.A.1.a.12. gives an execution time of 500 µs.

3. A. 1. b. Microwave or millimetre wave components, as follows:
   1. Electronic vacuum tubes and cathodes, as follows:
      Note 3.A.1.b.1. does not control tubes designed or rated for operation in any frequency band which meets all of the following characteristics:
      a. Does not exceed 31 GHz; and
      b. Is "allocated by the ITU" for radio-communications services, but not for radio-determination.

      a. Travelling wave tubes, pulsed or continuous wave, as follows:
         1. Operating at frequencies exceeding 31 GHz;
         2. Having a cathode heater element with a turn on time to rated RF power of less than 3 seconds;
         3. Coupled cavity tubes, or derivatives thereof, with a "fractional bandwidth" of more than 7% or a peak power exceeding 2.5 kW;

Dual-Use List - Category 3 - ELECTRONICS

4. Helix tubes, or derivatives thereof, with any of the following characteristics:
   a. An "instantaneous bandwidth" of more than one octave, and average power (expressed in kW) times frequency (expressed in GHz) of more than 0.5;
   b. An "instantaneous bandwidth" of one octave or less, and average power (expressed in kW) times frequency (expressed in GHz) of more than 1; or
   c. Being "space qualified";

b. Crossed-field amplifier tubes with a gain of more than 17 dB;

c. Impregnated cathodes designed for electronic tubes producing a continuous emission current density at rated operating conditions exceeding 5 A/cm^2;

3. A. 1. b. 2. Microwave integrated circuits or modules having all of the following:
   a. Containing "monolithic integrated circuits" having one or more active circuit elements; and
   b. Operating at frequencies exceeding 3 GHz;

   Note 1 *3.A.1.b.2. does not control circuits or modules for equipment designed or rated for operation in any frequency band which meets all of the following characteristics:*
   a. Does not exceed 31 GHz; and
   b. Is "allocated by the ITU" for radio-communications services, but not for radio-determination.

   Note 2 *3.A.1.b.2. does not control broadcast satellite equipment designed or rated to operate in the frequency range of 40.5 to 42.5 GHz.*

3. A. 1. b. 3. Microwave transistors rated for operation at frequencies exceeding 31 GHz;

4. Microwave solid state amplifiers, having any of the following:
   a. Operating frequencies exceeding 10.5 GHz and an "instantaneous bandwidth" of more than half an octave; or
   b. Operating frequencies exceeding 31 GHz;

5. Electronically or magnetically tunable band-pass or band-stop filters having more than 5 tunable resonators capable of tuning across a 1.5:1 frequency band (f_{max}/f_{min}) in less than 10 µs having any of the following:
   a. A band-pass bandwidth of more than 0.5% of centre frequency; or
   b. A band-stop bandwidth of less than 0.5% of centre frequency;

6. Microwave assemblies capable of operating at frequencies exceeding 31 GHz;

7. Mixers and converters designed to extend the frequency range of equipment described in 3.A.2.c., 3.A.2.e. or 3.A.2.f. beyond the limits stated therein;

8. Microwave power amplifiers containing tubes controlled by 3.A.1.b. and having all of the following:

Dual-Use List - Category 3 - ELECTRONICS

a. Operating frequencies above 3 GHz;
b. An average output power density exceeding 80 W/kg; and
c. A volume of less than 400 cm^3;

Note 3.A.1.b.8. does not control equipment designed or rated for operation in any frequency band which is "allocated by the ITU" for radio-communications services, but not for radio-determination.

3. A. 1. c. Acoustic wave devices, as follows, and specially designed components therefor:

1. Surface acoustic wave and surface skimming (shallow bulk) acoustic wave devices (i.e., "signal processing" devices employing elastic waves in materials), having any of the following:
   a. A carrier frequency exceeding 2.5 GHz;
   b. A carrier frequency exceeding 1 GHz, but not exceeding 2.5 GHz, and having any of the following:
      1. A frequency side-lobe rejection exceeding 55 dB;
      2. A product of the maximum delay time and the bandwidth (time in μs and bandwidth in MHz) of more than 100;
      3. A bandwidth greater than 250 MHz; or
      4. A dispersive delay of more than 10 μs; or

   c. A carrier frequency of 1 GHz or less, having any of the following:
      1. A product of the maximum delay time and the bandwidth (time in μs and bandwidth in MHz) of more than 100;
      2. A dispersive delay of more than 10 μs; or
      3. A frequency side-lobe rejection exceeding 55 dB and a bandwidth greater than 50 MHz;
2. Bulk (volume) acoustic wave devices (i.e., "signal processing" devices employing elastic waves) which permit the direct processing of signals at frequencies exceeding 1 GHz;

3. Acoustic-optic "signal processing" devices employing interaction between acoustic waves (bulk wave or surface wave) and light waves which permit the direct processing of signals or images, including spectral analysis, correlation or convolution;

3. A. 1. d. Electronic devices and circuits containing components, manufactured from "superconductive" materials specially designed for operation at temperatures below the "critical temperature" of at least one of the "superconductive" constituents, with any of the following:
1. Current switching for digital circuits using "superconductive" gates with a product of delay time per gate (in seconds) and power dissipation per gate (in watts) of less than 10^{-14} J; or
2. Frequency selection at all frequencies using resonant circuits with Q-values exceeding 10,000;

Dual-Use List - Category 3 - ELECTRONICS

3. A. 1. e. High energy devices, as follows:

1. Batteries and photovoltaic arrays, as follows:
Note 3.A.1.e.1. does not control batteries with volumes equal to or less than 27 cm^3 (e.g., standard C-cells or R14 batteries).

a. Primary cells and batteries having an energy density exceeding 480 Wh/kg and rated for operation in the temperature range from below 243 K (-30°C) to above 343 K (70°C);

b. Rechargeable cells and batteries having an energy density exceeding 150 Wh/kg after 75 charge/discharge cycles at a discharge current equal to C/5 hours (C being the nominal capacity in ampere hours) when operating in the temperature range from below 253 K (-20°C) to above 333 K (60°C);

Technical Note
Energy density is obtained by multiplying the average power in watts (average voltage in volts times average current in amperes) by the duration of the discharge in hours to 75% of the open circuit voltage divided by the total mass of the cell (or battery) in kg.

c. "Space qualified" and radiation hardened photovoltaic arrays with a specific power exceeding 160 W/m^2 at an operating temperature of 301 K (28°C) under a tungsten illumination of 1 kW/m^2, at 2,800 K (2,527°C);

3. A. 1. e. 2. High energy storage capacitors, as follows:

a. Capacitors with a repetition rate of less than 10 Hz (single shot capacitors) having all of the following:
1. A voltage rating equal to or more than 5 kV;
2. An energy density equal to or more than 250 J/kg; and
3. A total energy equal to or more than 25 kJ;

b. Capacitors with a repetition rate of 10 Hz or more (repetition rated capacitors) having all of the following:
1. A voltage rating equal to or more than 5 kV;
2. An energy density equal to or more than 50 J/kg;
3. A total energy equal to or more than 100 J; and
4. A charge/discharge cycle life equal to or more than 10,000;

3. A. 1. e. 3. "Superconductive" electromagnets and solenoids specially designed to be fully charged or discharged in less than one second, having all of the following:
Note 3.A.1.e.3. does not control "superconductive" electromagnets or solenoids specially designed for Magnetic Resonance Imaging (MRI) medical equipment.

3. A. 1. e. 3. a. Energy delivered during the discharge exceeding 10 kJ in the first second;
b. Inner diameter of the current carrying windings of more than 250 mm; and
c. Rated for a magnetic induction of more than 8 T or "overall current density" in the winding of more than 300 A/mm^2;

Dual-Use List - Category 3 - ELECTRONICS

3. A. 1. f. Rotary input type shaft absolute position encoders having any of the following:
   1. A resolution of better than 1 part in 265,000 (18 bit resolution) of full scale; or
   2. An accuracy better than ± 2.5 seconds of arc.

3. A. 2. General purpose electronic equipment, as follows:

a. Recording equipment, as follows, and specially designed test tape therefor:
   1. Analogue instrumentation magnetic tape recorders, including those permitting the recording of digital signals (e.g., using a high density digital recording (HDDR) module), having any of the following:
      a. A bandwidth exceeding 4 MHz per electronic channel or track;
      b. A bandwidth exceeding 2 MHz per electronic channel or track and having more than 42 tracks; or
      c. A time displacement (base) error, measured in accordance with applicable IRIG or EIA documents, of less than ± 0.1 µs;

Note *Analogue magnetic tape recorders specially designed for civilian video purposes are not considered to be instrumentation tape recorders.*

3. A. 2. a. 2. Digital video magnetic tape recorders having a maximum digital interface transfer rate exceeding 360 Mbit/s;

Note *3.A.2.a.2. does not control digital video magnetic tape recorders specially designed for television recording using a signal format, which may include a compressed signal format, standardised or recommended by the ITU, the IEC, the SMPTE, the EB U or the IEEE for civil television applications.*

3. Digital instrumentation magnetic tape data recorders employing helical scan techniques or fixed head techniques, having any of the following:
   a. A maximum digital interface transfer rate exceeding 175 Mbit/s; or
   b. Being "space qualified";

Note *3.A.2.a.3 does not control analogue magnetic tape recorders equipped with HDDR conversion electronics and configured to record only digital data.*

4. Equipment, having a maximum digital interface transfer rate exceeding 175 Mbit/s, designed to convert digital video magnetic tape recorders for use as digital instrumentation data recorders;

3. A. 2. a. 5. Waveform digitisers and transient recorders having all of the following:
   a. Digitising rates equal to or more than 200 million samples per second and a resolution of 10 bits or more; and
   b. A continuous throughput of 2 Gbit/s or more;

Technical Note

For those instruments with a parallel bus architecture, the continuous throughput rate is the highest word rate multiplied by the number of bits in a word.

Continuous throughput is the fastest data rate the instrument can output to mass storage without the loss of any information whilst sustaining the sampling rate and analogue-to-digital conversion.

Dual-Use List - Category 3 - ELECTRONICS

3. A. 2. b. "Frequency synthesiser" "electronic assemblies" having a "frequency switching time" from one selected frequency to another of less than 1 ms;

c. "Signal analysers", as follows:
1. "Signal analysers" capable of analysing frequencies exceeding 31 GHz;
2. "Dynamic signal analysers" having a "real-time bandwidth" exceeding 500 kHz;
Note 3.A.2.c.2. does not control those "dynamic signal analysers" using only constant percentage bandwidth filters (also known as octave or fractional octave filters).

d. Frequency synthesised signal generators producing output frequencies, the accuracy and short term and long term stability of which are controlled, derived from or disciplined by the internal master frequency, and having any of the following:
1. A maximum synthesised frequency exceeding 31 GHz;
2. A "frequency switching time" from one selected frequency to another of less than 1 ms; or
3. A single sideband (SSB) phase noise better than $-(126+20 \log_{10}F - 20 \log_{10}f)$ in dBc/Hz, where F is the offset from the operating frequency in Hz and f is the operating frequency in MHz;
Note 3.A.2.d. does not control equipment in which the output frequency is either produced by the addition or subtraction of two or more crystal oscillator frequencies, or by an addition or subtraction followed by a multiplication of the result.

e. Network analysers with a maximum operating frequency exceeding 40 GHz;

f. Microwave test receivers having all of the following:
1. A maximum operating frequency exceeding 40 GHz; and
2. Being capable of measuring amplitude and phase simultaneously;

3. A. 2. g. Atomic frequency standards having any of the following:
1. Long-term stability (aging) less (better) than 1×10^{-11}/month; or
2. Being "space qualified".
Note 3.A.2.g.1. does not control non-"space qualified" rubidium standards.

3. B. TEST, INSPECTION AND PRODUCTION EQUIPMENT

3. B. 1. Equipment for the manufacturing of semiconductor devices or materials, as follows, and specially designed components and accessories therefor:
a. "Stored programme controlled" equipment designed for epitaxial growth, as follows:
1. Equipment capable of producing a layer thickness uniform to less than ±2.5% across a distance of 75 mm or more;
2. Metal organic chemical vapour deposition (MOCVD) reactors specially designed for compound semiconductor crystal growth by the chemical reaction between materials controlled by 3.C.3 or 3.C.4.;
3. Molecular beam epitaxial growth equipment using gas or solid sources;

3. B. 1. b. [Deleted]

Dual-Use List - Category 3 - ELECTRONICS

3. B. 1. c. "Stored programme controlled" anisotropic plasma dry etching equipment, as follows:
   1. Equipment with cassette-to-cassette operation and load-locks, and having any of the following:
      a. Designed or optimised to produce critical dimensions of 0.3 µm or less with ±5% 3 sigma precision; or
      b. Designed for generating less than 0.04 particles/cm^2 with a measurable particle size greater than 0.1 µm in diameter;

   2. Equipment specially designed for equipment controlled by 3.B.1.e. and having any of the following:
      a. Designed or optimised to produce critical dimensions of 0.3 µm or less with ±5% 3 sigma precision; or
      b. Designed for generating less than 0.04 particles/cm^2 with a measurable particle size greater than 0.1 µm in diameter;

3. B. 1. d. "Stored programme controlled" plasma enhanced CVD equipment, as follows:
   1. Equipment with cassette-to-cassette operation and load-locks, and having any of the following:
      a. Designed according to the manufacturer's specifications or optimised to produce critical dimensions of 0.3 µm or less with ±5% 3 sigma precision; or
      b. Designed for generating less than 0.04 particles/cm^2 with a measurable particle size greater than 0.1 µm in diameter;

   2. Equipment specially designed for equipment controlled by 3.B.1.e. and having any of the following:
      a. Designed according to the manufacturer's specifications or optimised to produce critical dimensions of 0.3 µm or less with ±5% 3 sigma precision; or
      b. Designed for generating less than 0.04 particles/cm^2 with a measurable particle size greater than 0.1 µm in diameter;

3. B. 1. e. "Stored programme controlled" automatic loading multi-chamber central wafer handling systems, having all of the following:
   1. Interfaces for wafer input and output, to which more than two pieces of semiconductor processing equipment are to be connected; and
   2. Designed to form an integrated system in a vacuum environment for sequential multiple wafer processing;

   Note 3.B.1.e. does not control automatic robotic wafer handling systems not designed to operate in a vacuum environment.

Dual-Use List - Category 3 - ELECTRONICS

3. B. 1. f. "Stored programme controlled" lithography equipment, as follows:

1. Align and expose step and repeat (direct step on wafer) or step and scan (scanner) equipment for wafer processing using photo-optical or X-ray methods, having any of the following:
   a. A light source wavelength shorter than 350 nm; or
   b. Capable of producing a pattern with a minimum resolvable feature size of 0.5 µm or less;

   Technical Note
   The minimum resolvable feature size is calculated by the following formula:

$$MRF = \frac{\text{(an exposure light source wavelength in µm) x (Kfactor)}}{\text{numerical aperture}}$$

   where the Kfactor = 0.7.
   MRF = minimum resolvable feature size.

3. B. 1. f. 2. Equipment specially designed for mask making or semiconductor device processing using deflected focussed electron beam, ion beam or "laser" beam, having any of the following:
   a. A spot size smaller than 0.2 µm;
   b. Being capable of producing a pattern with a feature size of less than 1 µm; or
   c. An overlay accuracy of better than ±0.20 µm (3 sigma);

g. Masks and reticles designed for integrated circuits controlled by 3.A.1.;

h. Multi-layer masks with a phase shift layer.

3. B. 2. "Stored programme controlled" test equipment, specially designed for testing finished or unfinished semiconductor devices, as follows, and specially designed components and accessories therefor:
   a. For testing S-parameters of transistor devices at frequencies exceeding 31 GHz;
   b. For testing integrated circuits capable of performing functional (truth table) testing at a pattern rate of more than 333 MHz;

   Note *3.B.2.b. does not control test equipment specially designed for testing:*
   1. "Electronic assemblies" or a class of "electronic assemblies" for home or entertainment applications;
   2. Uncontrolled electronic components, "electronic assemblies" or integrated circuits;
   3. Memories.

   Technical Note
   For the purpose of this entry, pattern rate is defined as the maximum frequency of digital operation of a tester. It is therefore equivalent to the highest data rate that a tester can provide in non-multiplexed mode. It is also referred to as test speed, maximum digital frequency or maximum digital speed.

3. B. 2. c. For testing microwave integrated circuits controlled by 3.A.1.b.2.;

Dual-Use List - Category 3 - ELECTRONICS

3. C. MATERIALS

3. C. 1. Hetero-epitaxial materials consisting of a "substrate" having stacked epitaxially grown multiple layers of any of the following:
   a. Silicon;
   b. Germanium;
   c. Silicon Carbide; or
   d. III/V compounds of gallium or indium.

   Technical Note
   III/V compounds are polycrystalline or binary or complex monocrystalline products consisting of elements of groups IIIA and VA of Mendeleyev's periodic classification table (e.g., gallium arsenide, gallium-aluminium arsenide, indium phosphide).

3. C. 2. Resist materials, as follows, and "substrates" coated with controlled resists:

   a. Positive resists designed for semiconductor lithography specially adjusted (optimised) for use at wavelengths below 350 nm;
   b. All resists designed for use with electron beams or ion beams, with a sensitivity of 0.01 μcoulomb/mm^2 or better;
   c. All resists designed for use with X-rays, with a sensitivity of 2.5 mJ/mm^2 or better;
   d. All resists optimised for surface imaging technologies, including silylated resists.

   Technical Note
   Silylation techniques are defined as processes incorporating oxidation of the resist surface to enhance performance for both wet and dry developing.

3. C. 3. Organo-inorganic compounds, as follows:
   a. Organo-metallic compounds of aluminium, gallium or indium having a purity (metal basis) better than 99.999%;
   b. Organo-arsenic, organo-antimony and organo-phosphorus compounds having a purity (inorganic element basis) better than 99.999%.

   Note *3.C.3. only controls compounds whose metallic, partly metallic or non-metallic element is directly linked to carbon in the organic part of the molecule.*

3. C. 4. Hydrides of phosphorus, arsenic or antimony, having a purity better than 99.999%, even diluted in inert gases or hydrogen.

   Note *3.C.4. does not control hydrides containing 20% molar or more of inert gases or hydrogen.*

3. D. SOFTWARE

3. D. 1. "Software" specially designed for the "development" or "production" of equipment controlled by 3.A.1.b. to 3.A.2.g. or 3.B.

3. D. 2. "Software" specially designed for the "use" of "stored programme controlled" equipment controlled by 3.B.

Dual-Use List - Category 3 - ELECTRONICS

3. D. 3. Computer-aided-design (CAD) "software", having all of the following:
   a. Designed for the "development" of semiconductor devices or integrated circuits; and
   b. Designed to perform or use any of the following:
      1. Design rules or circuit verification rules;
      2. Simulation of the physically laid out circuits; or
      3. Lithographic processing simulators for design.

Technical Note
A lithographic processing simulator is a "software" package used in the design phase to define the sequence of lithographic, etching and deposition steps for translating masking patterns into specific topographical patterns in conductors, dielectrics or semiconductor material.

Note 1 *3.D.3. does not control "software" specially designed for schematic entry, logic simulation, placing and routing, layout verification or pattern generation tape.*

Note 2 *Libraries, design attributes or associated data for the design of semiconductor devices or integrated circuits are considered as "technology".*

3. E. TECHNOLOGY

3. E. 1. "Technology" according to the General Technology Note for the "development" or "production" of equipment or materials controlled by 3.A, 3.B or 3.C;

2. "Technology" according to the General Technology Note other than that controlled in 3.E.1. for the "development" or "production" of "microprocessor microcircuits", "micro-computer microcircuits" and microcontroller microcircuits having a "composite theoretical performance" ("CTP") of 530 million theoretical operations per second (Mtops) or more and an arithmetic logic unit with an access width of 32 bits or more.

Note *3.E.1. and 3.E.2. do not control "technology" for the "development" or "production" of:*
a. Microwave transistors operating at frequencies below 31 GHz;
b. Integrated circuits controlled by 3.A.1.a.3. to 3.A.1.a.12., having all of the following:
1. Using "technology" of 0.7 µm or more; and
2. Not incorporating multi-layer structures.

Technical Note
The term multi-layer structures in Note b.2. above does not include devices incorporating a maximum of two metal layers and two polysilicon layers.

3. E. 3. Other "technology" for the "development" or "production" of:
   a. Vacuum microelectronic devices;
   b. Hetero-structure semiconductor devices such as high electron mobility transistors (HEMT), hetero-bipolar transistors (HBT), quantum well and super lattice devices;
   c. "Superconductive" electronic devices;
   d. Substrates of films of diamond for electronic components;
   e. Substrates of silicon-on-insulator (SOI) for integrated circuits in which the insulator is silicon dioxide;
   f. Substrates of silicon carbide for electronic components.

Dual-Use List - Category 4 - COMPUTERS

4. COMPUTERS

Note 1 Computers, related equipment and "software" performing telecommunications or "local area network" functions must also be evaluated against the performance characteristics of Category 5, Part 1 (Telecommunications).

Note 2 Control units which directly interconnect the buses or channels of central processing units, "main storage" or disk controllers are not regarded as telecommunications equipment described in Category 5, Part 1 (Telecommunications).

N.B. For the control status of "software" specially designed for packet switching, see Category 5.D.1. (Telecommunications).

Note 3 Computers, related equipment and "software" performing cryptographic, cryptanalytic, certifiable multi-level security or certifiable user isolation functions, or which limit electromagnetic compatibility (EMC), must also be evaluated against the performance characteristics in Category 5, Part 2 ("Information Security").

4. A. SYSTEMS, EQUIPMENT AND COMPONENTS

4. A. 1. Electronic computers and related equipment, as follows, and "electronic assemblies" and specially designed components therefor:

a. Specially designed to have any of the following characteristics:

1. Rated for operation at an ambient temperature below 228 K (-45°C) or above 358 K (85°C);

Note 4.A.1.a.1. does not apply to computers specially designed for civil automobile or railway train applications.

2. Radiation hardened to exceed any of the following specifications:

a.	Total Dose	5×10^3 Gy (Si);
b.	Dose Rate Upset	5×10^6 Gy (Si)/sec; or
c.	Single Event Upset	1×10^{-7} Error/bit/day;

b. Having characteristics or performing functions exceeding the limits in Category 5, Part 2 ("Information Security").

Note 4.A.1.b. does not control electronic computers and related equipment when accompanying their user for the user's personal use.

4. A. 2. "Hybrid computers", as follows, and "electronic assemblies" and specially designed components therefor:

a. Containing "digital computers" controlled by 4.A.3.;

b. Containing analogue-to-digital converters having all of the following characteristics:

1. 32 channels or more; and

2. A resolution of 14 bits (plus sign bit) or more with a conversion rate of 200,000 conversions/s or more.

Dual-Use List - Category 4 - COMPUTERS

4. A. 3. "Digital computers", "electronic assemblies", and related equipment therefor, as follows, and specially designed components therefor:

Note 1 *4.A.3. includes the following:*

a. Vector processors;
b. Array processors;
c. Digital signal processors;
d. Logic processors;
e. Equipment designed for "image enhancement";
f. Equipment designed for "signal processing".

Note 2 *The control status of the "digital computers" and related equipment described in 4.A.3 is determined by the control status of other equipment or systems provided:*

a. The "digital computers" or related equipment are essential for the operation of the other equipment or systems;
b. The "digital computers" or related equipment are not a "principal element" of the other equipment or systems; and
N.B.1 The control status of "signal processing" or "image enhancement" equipment specially designed for other equipment with functions limited to those required for the other equipment is determined by the control status of the other equipment even if it exceeds the "principal element" criterion.
N.B.2 For the control status of "digital computers" or related equipment for telecommunications equipment, see Category 5, Part 1 (Telecommunications).
c. The "technology" for the "digital computers" and related equipment is determined by 4.E.

4. A. 3. a. Designed or modified for "fault tolerance";

Note *For the purposes of 4.A.3.a., "digital computers" and related equipment are not considered to be designed or modified for "fault tolerance" if they utilise any of the following:*

1. Error detection or correction algorithms in "main storage";
2. The interconnection of two "digital computers" so that, if the active central processing unit fails, an idling but mirroring central processing unit can continue the system's functioning;
3. The interconnection of two central processing units by data channels or by using shared storage to permit one central processing unit to perform other work until the second central processing unit fails, at which time the first central processing unit takes over in order to continue the system's functioning; or
4. The synchronisation of two central processing units by "software" so that one central processing unit recognises when the other central processing unit fails and recovers tasks from the failing unit.

Dual-Use List - Category 4 - COMPUTERS

4. A. 3. b. "Digital computers" having a "composite theoretical performance" ("CTP") exceeding 28,000 Mtops;

c. "Electronic assemblies" specially designed or modified for enhancing performance by aggregation of "computing elements" ("CEs") so that the "CTP" of the aggregation exceeds the limit in 4.A.3.b.;

Note 1 *4.A.3.c. applies only to "electronic assemblies" and programmable interconnections not exceeding the limit in 4.A.3.b. when shipped as unintegrated "electronic assemblies". It does not apply to "electronic assemblies" inherently limited by nature of their design for use as related equipment controlled by 4.A.3.d., or 4.A.3.e.*

Note 2 *4.A.3.c. does not control "electronic assemblies" specially designed for a product or family of products whose maximum configuration does not exceed the limit of 4.A.3.b.*

d. Graphics accelerators and graphics coprocessors exceeding a "three dimensional Vector Rate" of 200,000,000;

e. Equipment performing analogue-to-digital conversions exceeding the limits in 3.A.1.a.5;

f. Deleted;

g. Equipment specially designed to provide external interconnection of "digital computers" or associated equipment which allows communications at data rates exceeding 1,25 Gbyte/s.

Note *4.A.3.g. does not control internal interconnection equipment (e.g., backplanes, buses), passive interconnection equipment, "network access controllers" or "communications channel controllers".*

4. A. 4. Computers, as follows, and specially designed related equipment, "electronic assemblies" and components therefor:

a. "Systolic array computers";

b. "Neural computers";

c. "Optical computers"

Dual-Use List - Category 4 - COMPUTERS

4. B. TEST, INSPECTION AND PRODUCTION EQUIPMENT - None

4. C. MATERIALS - None

4. D. SOFTWARE

Note *The control status of "software" for the "development", "production", or "use" of equipment described in other Categories is dealt with in the appropriate Category. The control status of "software" for equipment described in this Category is dealt with herein.*

4. D. 1. "Software" specially designed or modified for the "development", "production" or "use" of equipment or "software" controlled by 4.A. or 4.D.

2. "Software" specially designed or modified to support "technology" controlled by 4.E.

3. Specific "software", as follows:

a. Operating system "software", "software" development tools and compilers specially designed for "multi-data-stream processing" equipment, in "source code";

b. Deleted

c. "Software" having characteristics or performing functions exceeding the limits in Category 5, Part 2 ("Information Security");
Note *4.D.3.c. does not control "software" when accompanying its user for the user's personal use.*

d. Operating systems specially designed for "real time processing" equipment which guarantees a "global interrupt latency time" of less than 20 µs.

4. E. TECHNOLOGY

4. E. 1. "Technology" according to the General Technology Note, for the "development", "production" or "use" of equipment or "software" controlled by 4.A. or 4.D.

Dual-Use List - Category 4 - COMPUTERS

TECHNICAL NOTE ON "COMPOSITE THEORETICAL PERFORMANCE" ("CTP")

Abbreviations used in this Technical Note

"CE"	*"computing element" (typically an arithmetic logical unit)*
FP	*floating point*
XP	*fixed point*
t	*execution time*
XOR	*exclusive OR*
CPU	*central processing unit*
TP	*theoretical performance (of a single "CE")*
"CTP"	*"composite theoretical performance" (multiple "CEs")*
R	*effective calculating rate*
WL	*word length*
L	*word length adjustment*
*	multiply

Execution time 't' is expressed in microseconds, TP and "CTP" are expressed in millions of theoretical operations per second (Mtops) and WL is expressed in bits.

Outline of "CTP" calculation method

"CTP" is a measure of computational performance given in Mtops. In calculating the "CTP" of an aggregation of "CEs" the following three steps are required:

1. Calculate the effective calculating rate R for each "CE";
2. Apply the word length adjustment (L) to the effective calculating rate (R), resulting in a Theoretical Performance (TP) for each "CE";
3. If there is more than one "CE", combine the TPs, resulting in a "CTP" for the aggregation.

Details for these steps are given in the following sections.

Note 1 For aggregations of multiple "CEs" which have both shared and unshared memory subsystems, the calculation of "CTP" is completed hierarchically, in two steps: first, aggregate the groups of "CEs" sharing memory; second, calculate the "CTP" of the groups using the calculation method for multiple "CEs" not sharing memory.

Note 2 "CEs" that are limited to input/output and peripheral functions (e.g., disk drive, communication and video display controllers) are not aggregated into the "CTP" calculation.

Dual-Use List - Category 4 - COMPUTERS

TECHNICAL NOTE ON "CTP"

The following table shows the method of calculating the Effective Calculating Rate R for each "CE":
Step 1: The effective calculating rate R

For "CEs" Implementing: Note Every "CE" must be evaluated independently.	Effective calculating Rate, R
XP only (R_{xp})	$\frac{1}{3*(t_{xp\ add})}$ if no add is implemented use: $\frac{1}{(t_{xp\ mult})}$ If neither add nor multiply is implemented use the fastest available arithmetic operation as follows: $\frac{1}{3*t_{xp}}$ See Notes X & Z
FP only (R_{fp})	$\max \frac{1}{t_{fp\ add}}, \frac{1}{t_{fp\ mult}}$ See Notes X & Y
Both FP and XP (R)	Calculate both R_{xp}, R_{fp}
For simple logic processors not implementing any of the specified arithmetic operations.	$\frac{1}{3*t_{log}}$ Where t_{log} is the execute time of the XOR, or for logic hardware not implementing the XOR, the fastest simple logic operation. See Notes X & Z
For special logic processors not using any of the specified arithmetic or logic operations.	$R = R' * WL/64$ Where R' is the number of results per second, WL is the number of bits upon which the logic operation occurs, and 64 is a factor to normalize to a 64 bit operation.

Dual-Use List - Category 4 - COMPUTERS

TECHNICAL NOTE ON "CTP"

Note W For a pipelined "CE" capable of executing up to one arithmetic or logic operation every clock cycle after the pipeline is full, a pipelined rate can be established. The effective calculating rate (R) for such a "CE" is the faster of the pipelined rate or non-pipelined execution rate.

Note X For a "CE" which performs multiple operations of a specific type in a single cycle (e.g., two additions per cycle or two identical logic operations per cycle), the execution time t is given by:

$$t = \frac{\text{cycle time}}{\text{the number of identical operations per machine cycle}}$$

"CEs" which perform different types of arithmetic or logic operations in a single machine cycle are to be treated as multiple separate "CEs" performing simultaneously (e.g., a "CE" performing an addition and a multiplication in one cycle is to be treated as two "CEs", the first performing an addition in one cycle and the second performing a multiplication in one cycle).
If a single "CE" has both scalar function and vector function, use the shorter execution time value.

Note Y For the "CE" that does not implement FP add or FP multiply, but that performs FP divide:

$$R_{fp} = \frac{1}{t_{fpdivide}}$$

If the "CE" implements FP reciprocal but not FP add, FP multiply or FP divide, then

$$R_{fp} = \frac{1}{t_{fpreciprocal}}$$

If none of the specified instructions is implemented, the effective FP rate is 0.

Note Z In simple logic operations, a single instruction performs a single logic manipulation of no more than two operands of given lengths.
In complex logic operations, a single instruction performs multiple logic manipulations to produce one or more results from two or more operands.

Dual-Use List - Category 4 - COMPUTERS

TECHNICAL NOTE ON "CTP"

Note Z

Rates should be calculated for all supported operand lengths considering both pipelined operations (if supported), and non-pipelined operations using the fastest executing instruction for each operand length based on:

1. Pipelined or register-to-register operations. Exclude extraordinarily short execution times generated for operations on a predetermined operand or operands (for example, multiplication by 0 or 1). If no register-to-register operations are implemented, continue with (2).
2. The faster of register-to-memory or memory-to-register operations; if these also do not exist, then continue with (3).
3. Memory-to-memory.

In each case above, use the shortest execution time certified by the manufacturer.

Step 2: TP for each supported operand length WL

Adjust the effective rate R (or R^1) by the word length adjustment L as follows:

$$TP = R * L,$$
$$\text{where } L = (1/3 + WL/96)$$

Note The word length WL used in these calculations is the operand length in bits. (If an operation uses operands of different lengths, select the largest word length.)

The combination of a mantissa ALU and an exponent ALU of a floating point processor or unit is considered to be one "CE" with a Word Length (WL) equal to the number of bits in the data representation (typically 32 or 64) for purposes of the "CTP" calculation.

This adjustment is not applied to specialized logic processors which do not use XOR instructions. In this case TP = R.

Select the maximum resulting value of TP for:

Each XP-only "CE" (R_{xp});
Each FP-only "CE" (R_{fp});
Each combined FP and XP "CE" (R);
Each simple logic processor not implementing any of the specified arithmetic operations;
and
Each special logic processor not using any of the specified arithmetic or logic operations.

Dual-Use List - Category 4 - COMPUTERS

TECHNICAL NOTE ON "CTP"

Step 3: "CTP" for aggregations of "CEs", including CPUs.

For a CPU with a single "CE",

"CTP" = TP

(for "CEs" performing both fixed and floating point operations

$TP = \max (TP_{fp}, TP_{xp})$)

"CTP" for aggregations of multiple "CEs" operating simultaneously is calculated as follows:

Note 1 For aggregations that do not allow all of the "CEs" to run simultaneously, the possible combination of "CEs" that provides the largest "CTP" should be used. The TP of each contributing "CE" is to be calculated at its maximum value theoretically possible before the "CTP" of the combination is derived.

N.B. To determine the possible combinations of simultaneously operating "CEs", generate an instruction sequence that initiates operations in multiple "CEs", beginning with the slowest "CE" (the one needing the largest number of cycles to complete its operation) and ending with the fastest "CE". At each cycle of the sequence, the combination of "CEs" that are in operation during that cycle is a possible combination. The instruction sequence must take into account all hardware and/or architectural constraints on overlapping operations.

Note 2 A single integrated circuit chip or board assembly may contain multiple "CEs".

Note 3 Simultaneous operations are assumed to exist when the computer manufacturer claims concurrent, parallel or simultaneous operation or execution in a manual or brochure for the computer.

Note 4 "CTP" values are not to be aggregated for "CE" combinations (inter)connected by "Local Area Networks", Wide Area Networks, I/O shared connections/devices, I/O controllers and any communication interconnection implemented by software.

Dual-Use List - Category 4 - COMPUTERS

TECHNICAL NOTE ON "CTP"

Note 5 "CTP" values must be aggregated for multiple "CEs" specially designed to enhance performance by aggregation, operating simultaneously and sharing memory,- or multiple memory/"CE"- combinations operating simultaneously utilising specially designed hardware.
This aggregation does not apply to "electronic assemblies" described in 4.A.3.c.

$$\text{"CTP"} = TP_1 + C_2 * TP_2 + \ldots + C_n * TP_n,$$

where the TPs are ordered by value, with TP_1 being the highest, TP_2 being the second highest, ..., and TP_n being the lowest. C_i is a coefficient determined by the strength of the interconnection between "CEs", as follows:

For multiple "CEs" operating simultaneously and sharing memory:

$$C_2 = C_3 = C_4 = \ldots = C_n = 0.75$$

Note 1 When the "CTP" calculated by the above method does not exceed 194 Mtops, the following formula may be used to calculate C_i:

$$C_i = \frac{0.75}{\sqrt{m}} \qquad (i = 2, \ldots, n)$$

where m = the number of "CEs" or groups of "CEs" sharing access.

provided:
1. The TP_i of each "CE" or group of "CEs" does not exceed 30 Mtops;
2. The "CEs" or groups of "CEs" share access to main memory (excluding cache memory) over a single channel; and
3. Only one "CE" or group of "CEs" can have use of the channel at any given time.

N.B. This does not apply to items controlled under Category 3.

Note 2 "CEs" share memory if they access a common segment of solid state memory. This memory may include cache memory, main memory or other internal memory. Peripheral memory devices such as disk drives, tape drives or RAM disks are not included.

Dual-Use List - Category 4 - COMPUTERS

TECHNICAL NOTE ON "CTP"

For Multiple "CEs" or groups of "CEs" not sharing memory, interconnected by one or more data channels:

$C_i = 0.75 * k_i$ $(i = 2, \ldots, 32)$ (see Note below)
$= 0.60 * k_i$ $(i = 33, \ldots, 64)$
$= 0.45 * k_i$ $(i = 65, \ldots, 256)$
$= 0.30 * k_i$ $(i > 256)$

The value of C_i is based on the number of "CEs", not the number of nodes.

where $k_i =$ min $(S_i/K_r, 1)$, and
$K_r =$ normalizing factor of 20 MByte/s.
$S_i =$ sum of the maximum data rates (in units of MByte/s) for all data channels connected to the i^{th} "CE" or group of "CEs" sharing memory.

When calculating a C_i for a group of "CEs", the number of the first "CE" in a group determines the proper limit for C_i. For example, in an aggregation of groups consisting of 3 "CEs" each, the 22nd group will contain $"CE"_{64}$, $"CE"_{65}$ and $"CE"_{66}$. The proper limit for C_i for this group is 0.60.

Aggregation (of "CEs" or groups of "CEs") should be from the fastest-to-slowest; i.e.:
$TP_1 \geq TP_2 \geq .... \geq TP_n$, and
in the case of $-TP_i = TP_i + 1$, from the largest to smallest; i.e.:
$C_i \geq C_i + 1$

Note The k_i factor is not to be applied to "CEs" 2 to 12 if the TP_i of the "CE" or group of "CEs" is more than 50 Mtops; i.e., C_i for "CEs" 2 to 12 is 0.75.

Dual-Use List - Category 5 - PART 1 TELECOMMUNICATIONS

Part 1 - TELECOMMUNICATIONS

Note 1 *The control status of components, "lasers", test and "production" equipment and "software" therefor which are specially designed for telecommunications equipment or systems is determined in Category 5, Part 1.*

Note 2 *"Digital computers", related equipment or "software", when essential for the operation and support of telecommunications equipment described in this Category, are regarded as specially designed components, provided they are the standard models customarily supplied by the manufacturer. This includes operation, administration, maintenance, engineering or billing computer systems.*

5. A. 1. SYSTEMS, EQUIPMENT AND COMPONENTS

a. Any type of telecommunications equipment having any of the following characteristics, functions or features:

1. Specially designed to withstand transitory electronic effects or electromagnetic pulse effects, both arising from a nuclear explosion;
2. Specially hardened to withstand gamma, neutron or ion radiation; or
3. Specially designed to operate outside the temperature range from 218 K (-55°C) to 397 K (124°C).
   Note *5.A.1.a.3. applies only to electronic equipment.*

Note *5.A.1.a.2. and 5.A.1.a.3. do not control equipment designed or modified for use on board satellites.*

5. A. 1. b. Telecommunication transmission equipment and systems, and specially designed components and accessories therefor, having any of the following characteristics, functions or features:

1. Being underwater communications systems having any of the following characteristics:
   a. An acoustic carrier frequency outside the range from 20 kHz to 60 kHz;
   b. Using an electromagnetic carrier frequency below 30 kHz; or
   c. Using electronic beam steering techniques;

Dual-Use List - Category 5 - PART 1 TELECOMMUNICATIONS

5. A. 1. b. 2. Being radio equipment operating in the 1.5 MHz to 87.5 MHz band and having any of the following characteristics:
   a. Incorporating adaptive techniques providing more than 15 dB suppression of an interfering signal; or
   b. Having all of the following:
      1. Automatically predicting and selecting frequencies and "total digital transfer rates" per channel to optimise the transmission; and
      2. Incorporating a linear power amplifier configuration having a capability to support multiple signals simultaneously at an output power of 1 kW or more in the 1.5 MHz to 30 MHz frequency range or 250 W or more in the 30 MHz to 87.5 MHz frequency range, over an "instantaneous bandwidth" of one octave or more and with an output harmonic and distortion content of better than -80 dB;

5. A. 1. b. 3. Being radio equipment employing "spread spectrum" techniques, including "frequency hopping" techniques, having any of the following characteristics:
   a. User programmable spreading codes; or
   b. A total transmitted bandwidth which is 100 or more times the bandwidth of any one information channel and in excess of 50 kHz;
      Note *5.A.1.b.3.b. does not control radio equipment specially designed for use with civil cellular radio-communications systems.*

   Note *5.A.1.b.3. does not control equipment designed to operate at an output power of 1.0 Watt or less.*

5. A. 1. b. 4. Being digitally controlled radio receivers having all of the following:
   a. More than 1,000 channels;
   b. A "frequency switching time" of less than 1 ms;
   c. Automatic searching or scanning of a part of the electromagnetic spectrum; and
   d. Identification of the received signals or the type of transmitter; or

   Note *5.A.1.b.4. does not control radio equipment specially designed for use with civil cellular radio-communications systems.*

5. A. 1. b. 5. Employing functions of digital "signal processing" to provide voice coding at rates of less than 2,400 bit/s.

Dual-Use List - Category 5 - PART 1 TELECOMMUNICATIONS

5. A. 1. c. 1. [Deleted]

2. Optical fibre cables and accessories designed for underwater use.

Note *5.A.1.c.2. does not control standard civil telecommunication cables and accessories.*

N.B.1 *For underwater umbilical cables, and connectors therefor, see 8.A.2.a.3.*

N.B.2 *For fibre-optic hull penetrators or connectors, see 8.A.2.c.*

5. A. 1. d. "Electronically steerable phased array antennae" operating above 31 GHz.

Note *5.A.1.d. does not control "electronically steerable phased array antennae" for landing systems with instruments meeting ICAO standards covering microwave landing systems (MLS).*

5. B. 1. TEST, INSPECTION AND PRODUCTION EQUIPMENT

5. B. 1. a. Equipment and specially designed components or accessories therefor, specially designed for the "development", "production" or "use" of equipment, functions or features controlled by Category 5 - Part 1.

Note *5.B.1.a. does not control optical fibre characterization equipment not using semiconductor "lasers".*

5. B. 1. b. Equipment and specially designed components or accessories therefor, specially designed for the "development" of any of the following telecommunication transmission or "stored programme controlled" switching equipment:

1. Equipment employing digital techniques, including "Asynchronous Transfer Mode" ("ATM"), designed to operate at a "total digital transfer rate" exceeding 1.5 Gbit/s;

Dual-Use List - Category 5 - PART 1 TELECOMMUNICATIONS

5. B. 1. b. 2. Equipment employing a "laser" and having any of the following:
   a. A transmission wavelength exceeding 1750 nm;
   b. Performing "optical amplification";
   c. Employing coherent optical transmission or coherent optical detection techniques (also called optical heterodyne or homodyne techniques); or
   d. Employing analogue techniques and having a bandwidth exceeding 2.5 GHz;
   Note 5.B.1.b.2.d. does not control equipment specially designed for the "development" of commercial TV systems.

   3. Equipment employing "optical switching";

   4. Radio equipment employing quadrature-amplitude-modulation (QAM) techniques above level 128; or

   5. Equipment employing "common channel signalling" operating in either non-associated or quasi-associated mode of operation.

5. C. 1. MATERIALS - None

5. D. 1. SOFTWARE

5. D. 1. a. "Software" specially designed or modified for the "development", "production" or "use" of equipment, functions or features controlled by Category 5 - Part 1.

   b. "Software" specially designed or modified to support "technology" controlled by 5.E.1.

   c. Specific "software" as follows:
      1. "Software" specially designed or modified to provide characteristics, functions or features of equipment controlled by 5.A.1. or 5.B.1.;
      2. Deleted
      3. "Software", other than in machine-executable form, specially designed for "dynamic adaptive routing".

Dual-Use List - Category 5 - PART 1 TELECOMMUNICATIONS

5. D. 1. d. "Software" specially designed or modified for the "development" of any of the following telecommunication transmission or "stored programme controlled" switching equipment:
   1. Equipment employing digital techniques, including "Asynchronous Transfer Mode" ("ATM"), designed to operate at a "total digital transfer rate" exceeding 1.5 Gbit/s;
   2. Equipment employing a "laser" and having any of the following:
      a. A transmission wavelength exceeding 1750 nm; or
      b. Employing analogue techniques and having a bandwidth exceeding 2.5 GHz;
         Note *5.D.1.d.2.b. does not control "software" specially designed or modified for the "development" of commercial TV systems.*
   3. Equipment employing "optical switching"; or
   4. Radio equipment employing quadrature-amplitude-modulation (QAM) techniques above level 128.

5. E. 1. TECHNOLOGY

5. E. 1. a. "Technology" according to the General Technology Note for the "development", "production" or "use" (excluding operation) of equipment, functions or features or "software" controlled by Category 5 - Part 1.

   b. Specific "technologies", as follows:
      1. "Required" "technology" for the "development" or "production" of telecommunications equipment specially designed to be used on board satellites;
      2. "Technology" for the "development" or "use" of "laser" communication techniques with the capability of automatically acquiring and tracking signals and maintaining communications through exoatmosphere or sub-surface (water) media;
      3. "Technology" for the "development" of digital cellular radio systems;
      4. "Technology" for the "development" of "spread spectrum" techniques, including "frequency hopping" techniques.

   c. "Technology" according to the General Technology Note for the "development" or "production" of any of the following telecommunication transmission or "stored programme controlled" switching equipment, functions or features:
      1. Equipment employing digital techniques, including "Asynchronous Transfer Mode" ("ATM"), designed to operate at a "total digital transfer rate" exceeding 1.5 Gbit/s;
      2. Equipment employing a "laser" and having any of the following:
         a. A transmission wavelength exceeding 1750 nm;
         b. Performing "optical amplification" using praseodymium-doped fluoride fibre amplifiers (PDFFA);

5. E. 1. c. 2. c. Employing coherent optical transmission or coherent optical detection techniques (also called optical heterodyne or homodyne techniques);
         d. Employing wavelength division multiplexing techniques exceeding 8 optical carriers in a single optical window; or

Dual-Use List - Category 5 - PART 1 TELECOMMUNICATIONS

c. Employing analogue techniques and having a bandwidth exceeding 2.5 GHz;
Note *5.E.1.c.2.e. does not control "technology" for the "development" or "production" of commercial TV systems.*

3. Equipment employing "optical switching";

4. Radio equipment having any of the following:
a. Quadrature-amplitude-modulation (QAM) techniques above level 128;
or
b. Operating at input or output frequencies exceeding 31 GHz; or
Note *5.E.1.c.4.b. does not control "technology" for the "development" or "production" of equipment designed or modified for operation in any frequency band which is "allocated by the ITU" for radio-communications services, but not for radio-determination.*

5. Equipment employing "common channel signalling" operating in either non-associated or quasi-associated mode of operation.

Dual-Use List - Category 5 - PART 2 "INFORMATION SECURITY"

Part 2 - "INFORMATION SECURITY"

Note 1 *The control status of "information security" equipment, "software", systems, application specific "electronic assemblies", modules, integrated circuits, components or functions is determined in Category 5, Part 2 even if they are components or "electronic assemblies" of other equipment.*

Note 2 *Category 5 - Part 2 does not control products when accompanying their user for the user's personal use.*

Note 3 *Cryptography Note*

5.A.2. and 5.D.2. do not control items that meet all of the following:

a. Generally available to the public by being sold, without restriction, from stock at retail selling points by means of any of the following:
   1. Over-the-counter transactions;
   2. Mail order transactions;
   3. Electronic transactions; or
   4. Telephone call transactions;

b. The cryptographic functionality cannot easily be changed by the user;

c. Designed for installation by the user without further substantial support by the supplier; and

d. Deleted;

e. When necessary, details of the items are accessible and will be provided, upon request, to the appropriate authority in the exporter's country in order to ascertain compliance with conditions described in paragraphs a. to c. above.

Technical Note
In Category 5 - Part 2, parity bits are not included in the key length.

5. A. 2. SYSTEMS, EQUIPMENT AND COMPONENTS

a. Systems, equipment, application specific "electronic assemblies", modules and integrated circuits for "information security", as follows, and other specially designed components therefor:

N. B. *For the control of global navigation satellite systems receiving equipment containing or employing decryption (i.e. GPS or GLONASS), see 7.A.5.*

Dual-Use List - Category 5 - PART 2 "INFORMATION SECURITY"

5. A. 2. a. 1. Designed or modified to use "cryptography" employing digital techniques performing any cryptographic function other than authentication or digital signature having any of the following:

Technical Notes

1. Authentication and digital signature functions include their associated key management function.

2. Authentication includes all aspects of access control where there is no encryption of files or text except as directly related to the protection of passwords, Personal Identification Numbers (PINS) or similar data to prevent unauthorised access.

3. "Cryptography" does not include "fixed" data compression or coding techniques.

Note *5.A.2.a.1. includes equipment designed or modified to use "cryptography" employing analogue principles when implemented with digital techniques.*

5. A. 2. a. 1. a. A "symmetric algorithm" employing a key length in excess of 56 bits; or

b. An "asymmetric algorithm" where the security of the algorithm is based on any of the following:

1. Factorisation of integers in excess of 512 bits (e.g., RSA);
2. Computation of discrete logarithms in a multiplicative group of a finite field of size greater than 512 bits (e.g., Diffie-Hellman over Z/pZ); or
3. Discrete logarithms in a group other than mentioned in 5.A.2.a.1.b.2. in excess of 112 bits (e.g., Diffie-Hellman over an elliptic curve);

2. Designed or modified to perform cryptanalytic functions;

3. Deleted;

4. Specially designed or modified to reduce the compromising emanations of information-bearing signals beyond what is necessary for health, safety or electromagnetic interference standards;

5. Designed or modified to use cryptographic techniques to generate the spreading code for "spread spectrum" systems, including the hopping code for "frequency hopping" systems;

6. Designed or modified to provide certified or certifiable "multilevel security" or user isolation at a level exceeding Class B2 of the Trusted Computer System Evaluation Criteria (TCSEC) or equivalent;

7. Communications cable systems designed or modified using mechanical, electrical or electronic means to detect surreptitious intrusion.

Dual-Use List - Category 5 - PART 2 "INFORMATION SECURITY"

Note *5.A.2. does not control:*

a. "Personalised smart cards" where the cryptographic capability is restricted for use in equipment or systems excluded from control under entries b. to f. of this Note. If a "personalised smart card" has multiple functions, the control status of each function is assessed individually.

b. Receiving equipment for radio broadcast, pay television or similar restricted audience broadcast of the consumer type, without digital encryption except that exclusively used for sending the billing or programme-related information back to the broadcast providers;

c. Equipment where the cryptographic capability is not user-accessible and which is specially designed and limited to allow any of the following:
1. Execution of copy-protected software;
2. Access to any of the following:
a. Copy-protected contents stored on read-only media; or
b. Information stored in encrypted form on media (e.g. in connection with the protection of intellectual property rights) when the media is offered for sale in identical sets to the public; or
3. One-time copying of copyright protected audio/video data.

d. Cryptographic equipment specially designed and limited for banking use or money transactions;
Technical Note
'Money transactions' in 5.A.2. Note d. includes the collection and settlement of fares or credit functions.

e. Portable or mobile radiotelephones for civil use (e.g., for use with commercial civil cellular radiocommunications systems) that are not capable of end-to-end encryption;

f. Cordless telephone equipment not capable of end-to-end encryption where the maximum effective range of unboosted cordless operation (i.e., a single, unrelayed hop between terminal and home basestation) is less than 400 metres according to the manufacturer's specifications.

Dual-Use List - Category 5 - PART 2 "INFORMATION SECURITY"

5. B. 2. TEST, INSPECTION AND PRODUCTION EQUIPMENT

a. Equipment specially designed for:

1. The "development" of equipment or functions controlled by Category 5 - Part 2, including measuring or test equipment;
2. The "production" of equipment or functions controlled by Category 5 - Part 2, including measuring, test, repair or production equipment.

b. Measuring equipment specially designed to evaluate and validate the "information security" functions controlled by 5.A.2. or 5.D.2.

5. C. 2. MATERIALS - None

5. D. 2. SOFTWARE

a. "Software" specially designed or modified for the "development", "production" or "use" of equipment or "software" controlled by Category 5 - Part 2;
b. "Software" specially designed or modified to support "technology" controlled by 5.E.2.;
c. Specific "software", as follows:
1. "Software" having the characteristics, or performing or simulating the functions of the equipment controlled by 5.A.2. or 5.B.2.;
2. "Software" to certify "software" controlled by 5.D.2.c.1.

Note *5.D.2. does not control:*
a. "Software" required for the "use" of equipment excluded from control under the Note to 5.A.2.;
b. "Software" providing any of the functions of equipment excluded from control under the Note to 5.A.2.

5. E. 2. TECHNOLOGY

a. "Technology" according to the General Technology Note for the "development", "production" or "use" of equipment or "software" controlled by Category 5 - Part 2.

Dual-Use List - Category 6 - SENSORS AND LASERS

6. A. SYSTEMS, EQUIPMENT AND COMPONENTS

6. A. 1. ACOUSTICS

6. A. 1. a. Marine acoustic systems, equipment and specially designed components therefor, as follows:

6. A. 1. a. 1. Active (transmitting or transmitting-and-receiving) systems, equipment and specially designed components therefor, as follows:
Note 6.A.1.a.1. does not control:
- a. Depth sounders operating vertically below the apparatus, not including a scanning function exceeding ± 20°, and limited to measuring the depth of water, the distance of submerged or buried objects or fish finding;
- b. Acoustic beacons, as follows:
  1. Acoustic emergency beacons;
  2. Pingers specially designed for relocating or returning to an underwater position.

6. A. 1. a. 1. a. Wide-swath bathymetric survey systems designed for sea bed topographic mapping, having all of the following:
1. Being designed to take measurements at an angle exceeding 20° from the vertical;
2. Being designed to measure depths exceeding 600 m below the water surface; and
3. Being designed to provide any of the following:
   a. Incorporation of multiple beams any of which is less than 1.9°; or
   b. Data accuracies of better than 0.3% of water depth across the swath averaged over the individual measurements within the swath;

6. A. 1. a. 1. b. Object detection or location systems having any of the following:
1. A transmitting frequency below 10 kHz;
2. Sound pressure level exceeding 224 dB (reference 1 μPa at 1 m) for equipment with an operating frequency in the band from 10 kHz to 24 kHz inclusive;
3. Sound pressure level exceeding 235 dB (reference 1 μPa at 1 m) for equipment with an operating frequency in the band between 24 kHz and 30 kHz;
4. Forming beams of less than 1° on any axis and having an operating frequency of less than 100 kHz;
5. Designed to operate with an unambiguous display range exceeding 5,120 m; or
6. Designed to withstand pressure during normal operation at depths exceeding 1,000 m and having transducers with any of the following:
   a. Dynamic compensation for pressure; or
   b. Incorporating other than lead zirconate titanate as the transduction element;

Dual-Use List - Category 6 - SENSORS AND LASERS

6. A. 1. a. 1. c. Acoustic projectors, including transducers, incorporating piezoelectric, magnetostrictive, electrostrictive, electrodynamic or hydraulic elements operating individually or in a designed combination, having any of the following:

Note 1 *The control status of acoustic projectors, including transducers, specially designed for other equipment is determined by the control status of the other equipment.*

Note 2 *6.A.1.a.1.c. does not control electronic sources which direct the sound vertically only, or mechanical (e.g., air gun or vapour-shock gun) or chemical (e.g., explosive) sources.*

6. A. 1. a. 1. c. 1. An instantaneous radiated acoustic power density exceeding 0.01 $mW/mm^2/Hz$ for devices operating at frequencies below 10 kHz;

2. A continuously radiated acoustic power density exceeding 0.001 $mW/mm^2/Hz$ for devices operating at frequencies below 10 kHz; or

Technical Note
Acoustic power density is obtained by dividing the output acoustic power by the product of the area of the radiating surface and the frequency of operation.

3. Side-lobe suppression exceeding 22 dB;

6. A. 1. a. 1. d. Acoustic systems, equipment and specially designed components for determining the position of surface vessels or underwater vehicles designed to operate at a range exceeding 1,000 m with a positioning accuracy of less than 10 m rms (root mean square) when measured at a range of 1,000 m;
Note 6.A.1.a.1.d. includes:
a. Equipment using coherent "signal processing" between two or more beacons and the hydrophone unit carried by the surface vessel or underwater vehicle;
b. Equipment capable of automatically correcting speed-of-sound propagation errors for calculation of a point.

Dual-Use List - Category 6 - SENSORS AND LASERS

6. A. 1. a. 2. Passive (receiving, whether or not related in normal application to separate active equipment) systems, equipment and specially designed components therefor, as follows:

a. Hydrophones having any of the following characteristics:

Note *The control status of hydrophones specially designed for other equipment is determined by the control status of the other equipment.*

1. Incorporating continuous flexible sensors or assemblies of discrete sensor elements with either a diameter or length less than 20 mm and with a separation between elements of less than 20 mm;
2. Having any of the following sensing elements:
   a. Optical fibres;
   b. Piezoelectric polymers; or
   c. Flexible piezoelectric ceramic materials;
3. A hydrophone sensitivity better than -180 dB at any depth with no acceleration compensation;
4. When designed to operate at depths exceeding 35 m with acceleration compensation; or
5. Designed for operation at depths exceeding 1,000 m;

Technical Note

Hydrophone sensitivity is defined as twenty times the logarithm to the base 10 of the ratio of rms output voltage to a 1 V rms reference, when the hydrophone sensor, without a pre-amplifier, is placed in a plane wave acoustic field with an rms pressure of 1 μPa. For example, a hydrophone of -160 dB (reference 1 V per μPa) would yield an output voltage of 10^{-8} V in such a field, while one of -180 dB sensitivity would yield only 10^{-9} V output. Thus, -160 dB is better than -180 dB.

6. A. 1. a. 2. b. Towed acoustic hydrophone arrays having any of the following:

1. Hydrophone group spacing of less than 12.5 m;
2. Designed or able to be modified to operate at depths exceeding 35 m;

Technical Note

'Able to be modified' in 6.A.1.a.2.b.2. means having provisions to allow a change of the wiring or interconnections to alter hydrophone group spacing or operating depth limits. These provisions are: spare wiring exceeding 10% of the number of wires, hydrophone group spacing adjustment blocks or internal depth limiting devices that are adjustable or that control more than one hydrophone group.

Dual-Use List - Category 6 - SENSORS AND LASERS

6. A. 1. a. 2. b. 3. Heading sensors controlled by 6.A.1.a.2.d.;
4. Longitudinally reinforced array hoses;
5. An assembled array of less than 40 mm in diameter;
6. Multiplexed hydrophone group signals designed to operate at depths exceeding 35 m or having an adjustable or removable depth sensing device in order to operate at depths exceeding 35 m; or
7. Hydrophone characteristics specified in 6.A.1.a.2.a.;

6. A. 1. a. 2. c. Processing equipment, specially designed for towed acoustic hydrophone arrays, having "user accessible programmability" and time or frequency domain processing and correlation, including spectral analysis, digital filtering and beamforming using Fast Fourier or other transforms or processes;

6. A. 1. a. 2. d. Heading sensors having all of the following:
1. An accuracy of better than ± 0.5°; and
2. Designed to operate at depths exceeding 35 m or having an adjustable or removable depth sensing device in order to operate at depths exceeding 35 m;

6. A. 1. a. 2. e. Bottom or bay cable systems having any of the following:
1. Incorporating hydrophones specified in 6.A.1.a.2.a.; or
2. Incorporating multiplexed hydrophone group signal modules having all of the following characteristics:
   a. Designed to operate at depths exceeding 35 m or having an adjustable or removable depth sensing device in order to operate at depths exceeding 35 m; and
   b. Capable of being operationally interchanged with towed acoustic hydrophone array modules;

f. Processing equipment, specially designed for bottom or bay cable systems, having "user accessible programmability" and time or frequency domain processing and correlation, including spectral analysis, digital filtering and beamforming using Fast Fourier or other transforms or processes;

6. A. 1. b. Correlation-velocity sonar log equipment designed to measure the horizontal speed of the equipment carrier relative to the sea bed at distances between the carrier and the sea bed exceeding 500 m.

Dual-Use List - Category 6 - SENSORS AND LASERS

6. A. 2. OPTICAL SENSORS

a. Optical detectors, as follows:
Note *6.A.2.a. does not control germanium or silicon photodevices.*

1. "Space-qualified" solid-state detectors, as follows:
a. "Space-qualified" solid-state detectors, having all of the following:
1. A peak response in the wavelength range exceeding 10 nm but not exceeding 300 nm; and
2. A response of less than 0.1% relative to the peak response at a wavelength exceeding 400 nm;

b. "Space-qualified" solid-state detectors, having all of the following:
1. A peak response in the wavelength range exceeding 900 nm but not exceeding 1,200 nm; and
2. A response "time constant" of 95 ns or less;

c. "Space-qualified" solid-state detectors having a peak response in the wavelength range exceeding 1,200 nm but not exceeding 30,000 nm;

6. A. 2. a. 2. [Deleted]

6. A. 2. a. 3. Non-"space-qualified" "focal plane arrays", as follows:

Technical Note
Linear or two-dimensional multi-element detector arrays are referred to as "focal plane arrays".

Note 1 *6.A.2.a.3. includes photoconductive arrays and photovoltaic arrays.*
Note 2 *6.A.2.a.3. does not control:*
a. Silicon "focal plane arrays";
b. Multi-element (not to exceed 16 elements) encapsulated photoconductive cells using either lead sulphide or lead selenide;
c. Pyroelectric detectors using any of the following:
1. Triglycine sulphate and variants;
2. Lead-lanthanum-zirconium titanate and variants;
3. Lithium tantalate;
4. Polyvinylidene fluoride and variants; or
5. Strontium barium niobate and variants.

6. A. 2. a. 3. a. Non-"space-qualified" "focal plane arrays", having all of the following:
1. Individual elements with a peak response within the wavelength range exceeding 900 nm but not exceeding 1,050 nm; and
2. A response "time constant" of less than 0.5 ns;

Dual-Use List - Category 6 - SENSORS AND LASERS

b. Non-"space-qualified" "focal plane arrays", having all of the following:
   1. Individual elements with a peak response in the wavelength range exceeding 1,050 nm but not exceeding 1,200 nm; and
   2. A response "time constant" of 95 ns or less;

c. Non-"space-qualified" "focal plane arrays", having individual elements with a peak response in the wavelength range exceeding 1,200 nm but not exceeding 30,000 nm.

6. A. 2. b. "Monospectral imaging sensors" and "multispectral imaging sensors" designed for remote sensing applications, having any of the following:
   1. An Instantaneous-Field-Of-View (IFOV) of less than 200 μr (microradians); or
   2. Being specified for operation in the wavelength range exceeding 400 nm but not exceeding 30,000 nm and having all of the following:
      a. Providing output imaging data in digital format; and
      b. Being any of the following:
         1. "Space-qualified"; or
         2. Designed for airborne operation, using other than silicon detectors, and having an IFOV of less than 2.5 mr (milliradians).

6. A. 2. c. Direct view imaging equipment operating in the visible or infrared spectrum, incorporating any of the following:
   1. Image intensifier tubes having the characteristics listed in 6.A.2.a.2.a.; or
   2. "Focal plane arrays" having the characteristics listed in 6.A.2.a.3.

Technical Note

'Direct view' refers to imaging equipment, operating in the visible or infrared spectrum, that presents a visual image to a human observer without converting the image into an electronic signal for television display, and that cannot record or store the image photographically, electronically or by any other means.

Note *6.A.2.c. does not control the following equipment incorporating other than GaAs or GaInAs photocathodes:*

a. Industrial or civilian intrusion alarm, traffic or industrial movement control or counting systems;
b. Medical equipment;
c. Industrial equipment used for inspection, sorting or analysis of the properties of materials;
d. Flame detectors for industrial furnaces;
e. Equipment specially designed for laboratory use.

6. A. 2. d. Special support components for optical sensors, as follows:
   1. "Space-qualified" cryocoolers;

Dual-Use List - Category 6 - SENSORS AND LASERS

2. Non-"space-qualified" cryocoolers, having a cooling source temperature below 218 K (-55°C), as follows:
   a. Closed cycle type with a specified Mean-Time-To-Failure (MTTF), or Mean-Time-Between-Failures (MTBF), exceeding 2,500 hours;
   b. Joule-Thomson (JT) self-regulating minicoolers having bore (outside) diameters of less than 8 mm;
3. Optical sensing fibres specially fabricated either compositionally or structurally, or modified by coating, to be acoustically, thermally, inertially, electromagnetically or nuclear radiation sensitive.

e. "Space qualified" "focal plane arrays" having more than 2,048 elements per array and having a peak response in the wavelength range exceeding 300 nm but not exceeding 900 nm.

6. A. 3. CAMERAS

N.B. For cameras specially designed or modified for underwater use, see 8.A.2.d. and 8.A.2.e.

6. A. 3. a. Instrumentation cameras and specially designed components therefor, as follows:
Note Instrumentation cameras, controlled by 6.A.3.a.3. to 6.A.3.a.5., with modular structures should be evaluated by their maximum capability, using plug-ins available according to the camera manufacturer's specifications.

1. High-speed cinema recording cameras using any film format from 8 mm to 16 mm inclusive, in which the film is continuously advanced throughout the recording period, and that are capable of recording at framing rates exceeding 13,150 frames/s;
Note 6.A.3.a.1. does not control cinema recording cameras designed for civil purposes.

2. Mechanical high speed cameras, in which the film does not move, capable of recording at rates exceeding 1,000,000 frames/s for the full framing height of 35 mm film, or at proportionately higher rates for lesser frame heights, or at proportionately lower rates for greater frame heights;

3. Mechanical or electronic streak cameras having writing speeds exceeding 10 mm/μs;

4. [Deleted]

5. Electronic cameras, having all of the following:
   a. An electronic shutter speed (gating capability) of less than 1 μs per full frame; and
   b. A read out time allowing a framing rate of more than 125 full frames per second.

6. Plug-ins, having all of the following characteristics:
   a. Specially designed for instrumentation cameras which have modular structures and which are controlled by 6.A.3.a.; and
   b. Enabling these cameras to meet the characteristics specified in 6.A.3.a.3., 6.A.3.a.4. or 6.A.3.a.5., according to the manufacturer's specifications.

Dual-Use List - Category 6 - SENSORS AND LASERS

6. A. 3. b. Imaging cameras, as follows:

Note *6.A.3.b. does not control television or video cameras specially designed for television broadcasting.*

1. Video cameras incorporating solid state sensors, having any of the following:
   a. More than 4 x 10^6 "active pixels" per solid state array for monochrome (black and white) cameras;
   b. More than 4 x 10^6 "active pixels" per solid state array for colour cameras incorporating three solid state arrays; or
   c. More than 12 x 10^6 "active pixels" for solid state array colour cameras incorporating one solid state array;

   Technical Note

   For the purpose of this entry, digital video cameras should be evaluated by the maximum number of "active pixels" used for capturing moving images.

2. Scanning cameras and scanning camera systems, having all of the following:
   a. Linear detector arrays with more than 8,192 elements per array; and
   b. Mechanical scanning in one direction;

3. Imaging cameras incorporating image intensifier tubes having the characteristics listed in 6.A.2.a.2.a.;

4. Imaging cameras incorporating "focal plane arrays" having the characteristics listed in 6.A.2.a.3.

   Note *6.A.3.b.4. does not control imaging cameras incorporating linear "focal plane arrays" with twelve elements or fewer, not employing time-delay-and-integration within the element, designed for any of the following:*
   a. Industrial or civilian intrusion alarm, traffic or industrial movement control or counting systems;
   b. Industrial equipment used for inspection or monitoring of heat flows in buildings, equipment or industrial processes;
   c. Industrial equipment used for inspection, sorting or analysis of the properties of materials;
   d. Equipment specially designed for laboratory use; or
   e. Medical equipment.

6. A. 4. OPTICS

a. Optical mirrors (reflectors), as follows:

1. "Deformable mirrors" having either continuous or multi-element surfaces, and specially designed components therefor, capable of dynamically repositioning portions of the surface of the mirror at rates exceeding 100 Hz;

Dual-Use List - Category 6 - SENSORS AND LASERS

6. A. 4. a. 2. Lightweight monolithic mirrors having an average "equivalent density" of less than 30 kg/m^2 and a total mass exceeding 10 kg;

3. Lightweight "composite" or foam mirror structures having an average "equivalent density" of less than 30 kg/m^2 and a total mass exceeding 2 kg;

4. Beam steering mirrors more than 100 mm in diameter or length of major axis, which maintain a flatness of lambda/2 or better (lambda is equal to 633 nm) having a control bandwidth exceeding 100 Hz.

6. A. 4. b. Optical components made from zinc selenide (ZnSe) or zinc sulphide (ZnS) with transmission in the wavelength range exceeding 3,000 nm but not exceeding 25,000 nm and having any of the following:
1. Exceeding 100 cm^3 in volume; or
2. Exceeding 80 mm in diameter or length of major axis and 20 mm in thickness (depth).

6. A. 4. c. "Space-qualified" components for optical systems, as follows:
1. Lightweighted to less than 20% "equivalent density" compared with a solid blank of the same aperture and thickness;
2. Raw substrates, processed substrates having surface coatings (single-layer or multi-layer, metallic or dielectric, conducting, semiconducting or insulating) or having protective films;
3. Segments or assemblies of mirrors designed to be assembled in space into an optical system with a collecting aperture equivalent to or larger than a single optic 1 m in diameter;
4. Manufactured from "composite" materials having a coefficient of linear thermal expansion equal to or less than 5 x 10^{-6} in any coordinate direction.

6. A. 4. d. Optical control equipment, as follows:
1. Specially designed to maintain the surface figure or orientation of the "space-qualified" components controlled by 6.A.4.c.1. or 6.A.4.c.3.;
2. Having steering, tracking, stabilisation or resonator alignment bandwidths equal to or more than 100 Hz and an accuracy of 10 µr (microradians) or less;

3. Gimbals having all of the following:
a. A maximum slew exceeding 5°;
b. A bandwidth of 100 Hz or more;
c. Angular pointing errors of 200 µr (microradians) or less; and
d. Having any of the following:
1. Exceeding 0.15 m but not exceeding 1 m in diameter or major axis length and capable of angular accelerations exceeding 2 r (radians)/s^2; or
2. Exceeding 1 m in diameter or major axis length and capable of angular accelerations exceeding 0.5 r (radians)/s^2;

4. Specially designed to maintain the alignment of phased array or phased segment mirror systems consisting of mirrors with a segment diameter or major axis length of 1 m or more.

Dual-Use List - Category 6 - SENSORS AND LASERS

6. A. 4. e. Aspheric optical elements having all of the following characteristics:
   1. The largest dimension of the optical-aperture is greater than 400 mm;
   2. The surface roughness is less than 1 nm (rms) for sampling lengths equal to or greater than 1 mm; and
   3. The coefficient of linear thermal expansion's absolute magnitude is less than $3x10^{-6}$/K at 25°C;

Technical Notes

1. An 'aspheric optical element' is any element used in an optical system whose imaging surface or surfaces are designed to depart from the shape of an ideal sphere.

2. Manufacturers are not required to measure the surface roughness listed in 6.A.4.e.2. unless the optical element was designed or manufactured with the intent to meet, or exceed, the control parameter.

Note 6.A.4.e. does not control aspheric optical elements having any of the following:
   a. A largest optical-aperture dimension less than 1 m and a focal length to aperture ratio equal to or greater than 4.5:1;
   b. A largest optical-aperture dimension equal to or greater than 1 m and a focal length to aperture ratio equal to or greater than 7:1;
   c. Being designed as Fresnel, flyeye, stripe, prism or diffractive optical elements;
   d. Being fabricated from borosilicate glass having a coefficient of linear thermal expansion greater than $2.5x10^{-6}$/K at 25°C; or
   e. Being an x-ray optical element having inner mirror capabilities (e.g. tube-type mirrors).

N. B. For aspheric optical elements specially designed for lithography equipment, see Item 3.B.1.

LASERS

6. A. 5. "Lasers", components and optical equipment, as follows:

Note 1 Pulsed "lasers" include those that run in a continuous wave (CW) mode with pulses superimposed.

Note 2 Pulse-excited "lasers" include those that run in a continuously excited mode with pulse excitation superimposed.

Note 3 The control status of Raman "lasers" is determined by the parameters of the pumping source "lasers". The pumping source "lasers" can be any of the "lasers" described below.

Dual-Use List - Category 6 - SENSORS AND LASERS

6. A. 5. a. Gas "lasers", as follows:
   1. Excimer "lasers", having any of the following:
      a. An output wavelength not exceeding 150 nm and having any of the following:
         1. An output energy exceeding 50 mJ per pulse; or
         2. An average output power exceeding 1 W;
      b. An output wavelength exceeding 150 nm but not exceeding 190 nm and having any of the following:
         1. An output energy exceeding 1.5 J per pulse; or
         2. An average output power exceeding 120 W;
      c. An output wavelength exceeding 190 nm but not exceeding 360 nm and having any of the following:
         1. An output energy exceeding 10 J per pulse; or
         2. An average output power exceeding 500 W; or
      d. An output wavelength exceeding 360 nm and having any of the following:
         1. An output energy exceeding 1.5 J per pulse; or
         2. An average output power exceeding 30 W;

      N. B. *For excimer "lasers" specially designed for lithography equipment, see 3.B.1.*

6. A. 5. a. 2. Metal vapour "lasers", as follows:
   a. Copper (Cu) "lasers" having an average output power exceeding 20 W;
   b. Gold (Au) "lasers" having an average output power exceeding 5 W;
   c. Sodium (Na) "lasers" having an output power exceeding 5 W;
   d. Barium (Ba) "lasers" having an average output power exceeding 2 W;

6. A. 5. a. 3. Carbon monoxide (CO) "lasers" having any of the following:
   a. An output energy exceeding 2 J per pulse and a pulsed "peak power" exceeding 5 kW; or
   b. An average or CW output power exceeding 5 kW;

6. A. 5. a. 4. Carbon dioxide (CO_2) "lasers" having any of the following:
   a. A CW output power exceeding 15 kW;
   b. A pulsed output having a "pulse duration" exceeding 10 µs and having any of the following:
      1. An average output power exceeding 10 kW; or
      2. A pulsed "peak power" exceeding 100 kW; or
   c. A pulsed output having a "pulse duration" equal to or less than 10 µs; and having any of the following:
      1. A pulse energy exceeding 5 J per pulse; or
      2. An average output power exceeding 2.5 kW;

Dual-Use List - Category 6 - SENSORS AND LASERS

6. A. 5. a. 5. "Chemical lasers", as follows:
   a. Hydrogen Fluoride (HF) "lasers";
   b. Deuterium Fluoride (DF) "lasers";
   c. "Transfer lasers", as follows:
      1. Oxygen Iodine (O_2-I) "lasers";
      2. Deuterium Fluoride-Carbon dioxide (DF-CO_2) "lasers";

6. A. 5. a. 6. Krypton ion or argon ion "lasers" having any of the following:
   a. An output energy exceeding 1.5 J per pulse and a pulsed "peak power" exceeding 50 W; or
   b. An average or CW output power exceeding 50 W;

6. A. 5. a. 7. Other gas "lasers", having any of the following:
   Note *6.A.5.a.7. does not control nitrogen "lasers".*

   a. An output wavelength not exceeding 150 nm and having any of the following:
      1. An output energy exceeding 50 mJ per pulse and a pulsed "peak power" exceeding 1 W; or
      2. An average or CW output power exceeding 1 W;

   b. An output wavelength exceeding 150 nm but not exceeding 800 nm and having any of the following:
      1. An output energy exceeding 1.5 J per pulse and a pulsed "peak power" exceeding 30 W; or
      2. An average or CW output power exceeding 30 W;

   c. An output wavelength exceeding 800 nm but not exceeding 1,400 nm and having any of the following:
      1. An output energy exceeding 0.25 J per pulse and a pulsed "peak power" exceeding 10 W; or
      2. An average or CW output power exceeding 10 W; or

   d. An output wavelength exceeding 1,400 nm and an average or CW output power exceeding 1 W.

6. A. 5. b. Semiconductor "lasers", as follows:
   1. Individual single-transverse mode semiconductor "lasers", having all of the following:
      a. A wavelength of less than 950 nm or more than 2000 nm; and
      b. An average or CW output power exceeding 100 mW;

   2. Individual, multiple-transverse mode semiconductor "lasers" having all of the following:
      a. A wavelength of less than 950 nm or more than 2000 nm; and
      b. An average or CW output power exceeding 10 W.

Dual-Use List - Category 6 - SENSORS AND LASERS

6. A. 5. b. 3. Individual arrays of individual semiconductor "lasers", having any of the following:
   a. A wavelength of less than 950 nm and an average or CW output power exceeding 60 W; or
   b. A wavelength equal to or greater than 2000 nm and an average or CW output power exceeding 10 W;

Technical Note
Semiconductor "lasers" are commonly called "laser" diodes.
Note 1 *6.A.5.b. includes semiconductor "lasers" having optical output connectors (e.g. fibre optic pigtails).*
Note 2 *The control status of semiconductor "lasers" specially designed for other equipment is determined by the control status of the other equipment.*

6. A. 5. c. Solid state "lasers", as follows:
   1. "Tunable" "lasers" having any of the following:
      Note *6.A.5.c.1. includes titanium - sapphire ($Ti: Al_2O_3$), thulium - YAG (Tm: YAG), thulium - YSGG (Tm: YSGG), alexandrite ($Cr: BeAl_2O_4$) and colour centre "lasers".*
      a. An output wavelength less than 600 nm and having any of the following:
         1. An output energy exceeding 50 mJ per pulse and a pulsed "peak power" exceeding 1 W; or
         2. An average or CW output power exceeding 1 W;
      b. An output wavelength of 600 nm or more but not exceeding 1,400 nm and having any of the following:
         1. An output energy exceeding 1 J per pulse and a pulsed "peak power" exceeding 20 W; or
         2. An average or CW output power exceeding 20 W; or
      c. An output wavelength exceeding 1,400 nm and having any of the following:
         1. An output energy exceeding 50 mJ per pulse and a pulsed "peak power" exceeding 1 W; or
         2. An average or CW output power exceeding 1 W;

6. A. 5. c. 2. Non-"tunable" "lasers", as follows:
   Note *6.A.5.c.2. includes atomic transition solid state "lasers".*
   a. Neodymium glass "lasers", as follows:
      1. "Q-switched lasers" having any of the following:
         a. An output energy exceeding 20 J but not exceeding 50 J per pulse and an average output power exceeding 10 W; or
         b. An output energy exceeding 50 J per pulse;

      2. Non-"Q-switched lasers" having any of the following:
         a. An output energy exceeding 50 J but not exceeding 100 J per pulse and an average output power exceeding 20 W; or
         b. An output energy exceeding 100 J per pulse;

Dual-Use List - Category 6 - SENSORS AND LASERS

6. A. 5. c. 2. b. Neodymium-doped (other than glass) "lasers", having an output wavelength exceeding 1,000 nm but not exceeding 1,100 nm, as follows:

N.B. *For neodymium-doped (other than glass) "lasers" having an output wavelength not exceeding 1,000 nm or exceeding 1,100 nm, see 6.A.5.c.2.c.*

1. Pulse-excited, mode-locked, "Q-switched lasers" having a "pulse duration" of less than 1 ns and having any of the following:
   a. A "peak power" exceeding 5 GW;
   b. An average output power exceeding 10 W; or
   c. A pulsed energy exceeding 0.1 J;

2. Pulse-excited, "Q-switched lasers" having a pulse duration equal to or more than 1 ns, and having any of the following:
   a. A single-transverse mode output having:
      1. A "peak power" exceeding 100 MW;
      2. An average output power exceeding 20 W; or
      3. A pulsed energy exceeding 2 J; or
   b. A multiple-transverse mode output having:
      1. A "peak power" exceeding 400 MW;
      2. An average output power exceeding 2 kW; or
      3. A pulsed energy exceeding 2 J;

3. Pulse-excited, non-"Q-switched lasers", having:
   a. A single-transverse mode output having:
      1. A "peak power" exceeding 500 kW; or
      2. An average output power exceeding 150 W; or
   b. A multiple-transverse mode output having:
      1. A "peak power" exceeding 1 MW; or
      2. An average power exceeding 2 kW;

4. Continuously excited "lasers" having:
   a. A single-transverse mode output having:
      1. A "peak power" exceeding 500 kW; or
      2. An average or CW output power exceeding 150 W; or
   b. A multiple-transverse mode output having:
      1. A "peak power" exceeding 1 MW; or
      2. An average or CW output power exceeding 2 kW;

Dual-Use List - Category 6 - SENSORS AND LASERS

6. A. 5. c. 2. c. Other non-"tunable" "lasers", having any of the following:
   1. A wavelength less than 150 nm and having any of the following:
      a. An output energy exceeding 50 mJ per pulse and a pulsed "peak power" exceeding 1 W; or
      b. An average or CW output power exceeding 1 W;

   2. A wavelength of 150 nm or more but not exceeding 800 nm and having any of the following:
      a. An output energy exceeding 1.5 J per pulse and a pulsed "peak power" exceeding 30 W; or
      b. An average or CW output power exceeding 30 W;

   3. A wavelength exceeding 800 nm but not exceeding 1,400 nm, as follows:
      a. "Q-switched lasers" having:
         1. An output energy exceeding 0.5 J per pulse and a pulsed "peak power" exceeding 50 W; or
         2. An average output power exceeding:
            a. 10 W for single-transverse mode "lasers";
            b. 30 W for multiple-transverse mode "lasers";
      b. Non-"Q-switched lasers" having:
         1. An output energy exceeding 2 J per pulse and a pulsed "peak power" exceeding 50 W; or
         2. An average or CW output power exceeding 50 W; or

   4. A wavelength exceeding 1,400 nm and having any of the following:
      a. An output energy exceeding 100 mJ per pulse and a pulsed "peak power" exceeding 1 W; or
      b. An average or CW output power exceeding 1 W;

6. A. 5. d. Dye and other liquid "lasers", having any of the following:
   1. A wavelength less than 150 nm and:
      a. An output energy exceeding 50 mJ per pulse and a pulsed "peak power" exceeding 1 W; or
      b. An average or CW output power exceeding 1 W;

   2. A wavelength of 150 nm or more but not exceeding 800 nm and having any of the following:
      a. An output energy exceeding 1.5 J per pulse and a pulsed "peak power" exceeding 20 W;
      b. An average or CW output power exceeding 20 W; or
      c. A pulsed single longitudinal mode oscillator having an average output power exceeding 1 W and a repetition rate exceeding 1 kHz if the "pulse duration" is less than 100 ns;

Dual-Use List - Category 6 - SENSORS AND LASERS

6. A. 5. d. 3. A wavelength exceeding 800 nm but not exceeding 1,400 nm and having any of the following:
   a. An output energy exceeding 0.5 J per pulse and a pulsed "peak power" exceeding 10 W; or
   b. An average or CW output power exceeding 10 W; or

4. A wavelength exceeding 1,400 nm and having any of the following:
   a. An output energy exceeding 100 mJ per pulse and a pulsed "peak power" exceeding 1 W; or
   b. An average or CW output power exceeding 1 W;

6. A. 5. e. Components, as follows:

1. Mirrors cooled either by active cooling or by heat pipe cooling;
   Technical Note
   Active cooling is a cooling technique for optical components using flowing fluids within the subsurface (nominally less than 1 mm below the optical surface) of the optical component to remove heat from the optic.

2. Optical mirrors or transmissive or partially transmissive optical or electro-optical components specially designed for use with controlled "lasers";

6. A. 5. f. Optical equipment, as follows:

1. Dynamic wavefront (phase) measuring equipment capable of mapping at least 50 positions on a beam wavefront having any of the following:
   a. Frame rates equal to or more than 100 Hz and phase discrimination of at least 5% of the beam's wavelength; or
   b. Frame rates equal to or more than 1,000 Hz and phase discrimination of at least 20% of the beam's wavelength;
2. "Laser" diagnostic equipment capable of measuring "SHPL" system angular beam steering errors of equal to or less than 10 μrad;
3. Optical equipment and components specially designed for a phased-array "SHPL" system for coherent beam combination to an accuracy of lambda/10 at the designed wavelength, or 0.1 μm, whichever is the smaller;
4. Projection telescopes specially designed for use with "SHPL" systems.

Dual-Use List - Category 6 - SENSORS AND LASERS

MAGNETOMETERS

6. A. 6. "Magnetometers", "magnetic gradiometers", "intrinsic magnetic gradiometers" and compensation systems, and specially designed components therefor, as follows:

Note *6.A.6. does not control instruments specially designed for biomagnetic measurements for medical diagnostics.*

a. "Magnetometers" using "superconductive", optically pumped or nuclear precession (proton/Overhauser) "technology" having a "noise level" (sensitivity) lower (better) than 0.05 nT rms per square root Hz;

b. Induction coil "magnetometers" having a "noise level" (sensitivity) lower (better) than any of the following:
   1. 0.05 nT rms/square root Hz at frequencies of less than 1 Hz;
   2. 1×10^{-3} nT rms/square root Hz at frequencies of 1 Hz or more but not exceeding 10 Hz; or
   3. 1×10^{-4} nT rms/square root Hz at frequencies exceeding 10 Hz;

c. Fibre optic "magnetometers" having a "noise level" (sensitivity) lower (better) than 1 nT rms per square root Hz;

d. "Magnetic gradiometers" using multiple "magnetometers" controlled by 6.A.6.a., 6.A.6.b. or 6.A.6.c.;

e. Fibre optic "intrinsic magnetic gradiometers" having a magnetic gradient field "noise level" (sensitivity) lower (better) than 0.3 nT/m rms per square root Hz;

f. "Intrinsic magnetic gradiometers", using "technology" other than fibre-optic "technology", having a magnetic gradient field "noise level" (sensitivity) lower (better) than 0.015 nT/m rms per square root Hz;

g. Magnetic compensation systems for magnetic sensors designed for operation on mobile platforms;

h. "Superconductive" electromagnetic sensors, containing components manufactured from "superconductive" materials and having all of the following:
   1. Being designed for operation at temperatures below the "critical temperature" of at least one of their "superconductive" constituents (including Josephson effect devices or "superconductive" quantum interference devices (SQUIDS));
   2. Being designed for sensing electromagnetic field variations at frequencies of 1 kHz or less; and:

Dual-Use List - Category 6 - SENSORS AND LASERS

6. A. 6. h. 3. Having any of the following characteristics:
   a. Incorporating thin-film SQUIDS with a minimum feature size of less than 2 µm and with associated input and output coupling circuits;
   b. Designed to operate with a magnetic field slew rate exceeding 1 x 10^6 magnetic flux quanta per second;
   c. Designed to function without magnetic shielding in the earth's ambient magnetic field; or
   d. Having a temperature coefficient less (smaller) than 0.1 magnetic flux quantum/K.

GRAVIMETERS

6. A. 7. Gravity meters (gravimeters) and gravity gradiometers, as follows:

   a. Gravity meters designed or modified for ground use having a static accuracy of less (better) than 10 µgal;
      Note *6.A.7.a. does not control ground gravity meters of the quartz element (Worden) type.*

   b. Gravity meters designed for mobile platforms, having all of the following:
      1. A static accuracy of less (better) than 0.7 mgal; and
      2. An in-service (operational) accuracy of less (better) than 0.7 mgal having a time-to-steady-state registration of less than 2 minutes under any combination of attendant corrective compensations and motional influences;

   c. Gravity gradiometers.

RADAR

6. A. 8. Radar systems, equipment and assemblies having any of the following characteristics, and specially designed components therefor:

   Note *6.A.8. does not control:*
   a. Secondary surveillance radar (SSR);
   b. Car radar designed for collision prevention;
   c. Displays or monitors used for air traffic control (ATC) having no more than 12 resolvable elements per mm;
   d. Meteorological (weather) radar.

6. A. 8. a. Operating at frequencies from 40 GHz to 230 GHz and having an average output power exceeding 100 mW;

   b. Having a tunable bandwidth exceeding ± 6.25% of the centre operating frequency;
      Technical Note
      The centre operating frequency equals one half of the sum of the highest plus the lowest specified operating frequencies.

Dual-Use List - Category 6 - SENSORS AND LASERS

6. A. 8. c. Capable of operating simultaneously on more than two carrier frequencies; 6.

d. Capable of operating in synthetic aperture (SAR), inverse synthetic aperture (ISAR) radar mode, or sidelooking airborne (SLAR) radar mode;

e. Incorporating "electronically steerable phased array antennae";

f. Capable of heightfinding non-cooperative targets;
Note *6.A.8.f. does not control precision approach radar (PAR) equipment conforming to ICAO standards.*

g. Specially designed for airborne (balloon or airframe mounted) operation and having Doppler "signal processing" for the detection of moving targets;

h. Employing processing of radar signals using any of the following:
1. "Radar spread spectrum" techniques; or
2. "Radar frequency agility" techniques; 6.

i. Providing ground-based operation with a maximum "instrumented range" exceeding 185 km; 6.
Note *6.A.8.i. does not control:* 6.
a. Fishing ground surveillance radar;
b. Ground radar equipment specially designed for enroute air traffic control, provided that all the following conditions are met: 6.
1. It has a maximum "instrumented range" of 500 km or less;
2. It is configured so that radar target data can be transmitted only one way from the radar site to one or more civil ATC centres; 6.
3. It contains no provisions for remote control of the radar scan rate from the enroute ATC centre; and
4. It is to be permanently installed.
c. Weather balloon tracking radars.

j. Being "laser" radar or Light Detection and Ranging (LIDAR) equipment, having any of the following:
1. "Space-qualified"; or
2. Employing coherent heterodyne or homodyne detection techniques and having an angular resolution of less (better) than 20 μr (microradians);
Note *6.A.8.j. does not control LIDAR equipment specially designed for surveying or for meteorological observation.* 6.

6.

k. Having "signal processing" sub-systems using "pulse compression", with any of the following:
1. A "pulse compression" ratio exceeding 150; or
2. A pulse width of less than 200 ns; or 6.

Dual-Use List - Category 6 - SENSORS AND LASERS

6. A. 8. 1. Having data processing sub-systems with any of the following:

1. "Automatic target tracking" providing, at any antenna rotation, the predicted target position beyond the time of the next antenna beam passage;

Note *6.A.8.1.1. does not control conflict alert capability in ATC systems, or marine or harbour radar.*

2. Calculation of target velocity from primary radar having non-periodic (variable) scanning rates;
3. Processing for automatic pattern recognition (feature extraction) and comparison with target characteristic databases (waveforms or imagery) to identify or classify targets; or
4. Superposition and correlation, or fusion, of target data from two or more "geographically dispersed" and "interconnected radar sensors" to enhance and discriminate targets.

Note *6.A.8.1.4. does not control systems, equipment and assemblies used for marine traffic control.*

6. B. TEST, INSPECTION AND PRODUCTION EQUIPMENT

6. B. 1. ACOUSTICS - None

6. B. 2. OPTICAL SENSORS - None

6. B. 3. CAMERAS - None

OPTICS

6. B. 4. Optical equipment, as follows:

a. Equipment for measuring absolute reflectance to an accuracy of ± 0.1% of the reflectance value;

b. Equipment other than optical surface scattering measurement equipment, having an unobscured aperture of more than 10 cm, specially designed for the non-contact optical measurement of a non-planar optical surface figure (profile) to an "accuracy" of 2 nm or less (better) against the required profile.

Note *6.B.4. does not control microscopes.*

6. B. 5. LASERS - None

6. B. 6. MAGNETOMETERS - None

GRAVIMETERS

6. B. 7. Equipment to produce, align and calibrate land-based gravity meters with a static accuracy of better than 0.1 mgal.

Dual-Use List - Category 6 - SENSORS AND LASERS

RADAR

6. B. 8. Pulse radar cross-section measurement systems having transmit pulse widths of 100 ns or less and specially designed components therefor.

6. C. MATERIALS

6. C. 1. ACOUSTICS - None

OPTICAL SENSORS

6. C. 2. Optical sensor materials, as follows:

a. Elemental tellurium (Te) of purity levels of 99.9995% or more;

b. Single crystals (including epitaxial wafers) of any of the following:
1. Cadmium zinc telluride with zinc content of less than 6% by mole fraction;
2. Cadmium telluride (CdTe) of any purity level; or
3. Mercury cadmium telluride (HgCdTe) of any purity level.

Technical Note

Mole fraction is defined as the ratio of moles of ZnTe to the sum of the moles of CdTe and ZnTe present in the crystal.

6. C. 3. CAMERAS - None

OPTICS

6. C. 4. Optical materials, as follows:

a. Zinc selenide (ZnSe) and zinc sulphide (ZnS) "substrate blanks" produced by the chemical vapour deposition process, having any of the following:
1. A volume greater than 100 cm^3; or
2. A diameter greater than 80 mm having a thickness of 20 mm or more;

b. Boules of the following electro-optic materials:
1. Potassium titanyl arsenate (KTA);
2. Silver gallium selenide ($AgGaSe_2$);
3. Thallium arsenic selenide (Tl_3AsSe_3, also known as TAS);

c. Non-linear optical materials, having all of the following:
1. Third order susceptibility (chi 3) of 10^{-6} m^2/V^2 or more; and
2. A response time of less than 1 ms;

Dual-Use List - Category 6 - SENSORS AND LASERS

6. C. 4. d. "Substrate blanks" of silicon carbide or beryllium beryllium (Be/Be) deposited materials exceeding 300 mm in diameter or major axis length;

e. Glass, including fused silica, phosphate glass, fluorophosphate glass, zirconium fluoride (ZrF_4) and hafnium fluoride (HfF_4), having all of the following:
1. A hydroxyl ion (OH-) concentration of less than 5 ppm;
2. Integrated metallic purity levels of less than 1 ppm; and
3. High homogeneity (index of refraction variance) less than 5×10^{-6};

f. Synthetically produced diamond material with an absorption of less than 10^{-5} cm^{-1} for wavelengths exceeding 200 nm but not exceeding 14,000 nm.

LASERS

6. C. 5. Synthetic crystalline "laser" host material in unfinished form, as follows:
a. Titanium doped sapphire;
b. Alexandrite.

6. C. 6. MAGNETOMETERS - None

6. C. 7. GRAVIMETERS - None

6. C. 8. RADAR - None.

6. D. SOFTWARE

1. "Software" specially designed for the "development" or "production" of equipment controlled by 6.A.4., 6.A.5., 6.A.8. or 6.B.8.

2. "Software" specially designed for the "use" of equipment controlled by 6.A.2.b., 6.A.8. or 6.B.8.

3. Other "software", as follows:

ACOUSTICS

6. D. 3. a. "Software", as follows:

1. "Software" specially designed for acoustic beam forming for the "real time processing" of acoustic data for passive reception using towed hydrophone arrays;
2. "Source code" for the "real time processing" of acoustic data for passive reception using towed hydrophone arrays;
3. "Software" specially designed for acoustic beam forming for the "real time processing" of acoustic data for passive reception using bottom or bay cable systems;
4. "Source code" for the "real time processing" of acoustic data for passive reception using bottom or bay cable systems;

Dual-Use List - Category 6 - SENSORS AND LASERS

6. D. 3. b. OPTICAL SENSORS - None

c. CAMERAS - None

d. OPTICS - None

e. LASERS - None

MAGNETOMETERS

6. D. 3. f. "Software", as follows:

1. "Software" specially designed for magnetic compensation systems for magnetic sensors designed to operate on mobile platforms;
2. "Software" specially designed for magnetic anomaly detection on mobile platforms;

GRAVIMETERS

6. D. 3. g. "Software" specially designed to correct motional influences of gravity meters or gravity gradiometers;

RADAR

6. D. 3. h. "Software", as follows:

1. Air Traffic Control "software" application "programmes" hosted on general purpose computers located at Air Traffic Control centres and capable of any of the following:
   a. Processing and displaying more than 150 simultaneous "system tracks"; or
   b. Accepting radar target data from more than four primary radars;

2. "Software" for the design or "production" of radomes which:
   a. Are specially designed to protect the "electronically steerable phased array antennae" controlled by 6.A.8.e.; and
   b. Result in an antenna pattern having an 'average side lobe level' more than 40 dB below the peak of the main beam level.
   Technical Note
   'Average side lobe level' in 6.D.3.h.2.b. is measured over the entire array excluding the angular extent of the main beam and the first two side lobes on either side of the main beam.

Dual-Use List - Category 6 - SENSORS AND LASERS

6. E. TECHNOLOGY

6. E. 1. "Technology" according to the General Technology Note for the "development" of equipment, materials or "software" controlled by 6.A., 6.B., 6.C. or 6.D.

6. E. 2. "Technology" according to the General Technology Note for the "production" of equipment or materials controlled by 6.A., 6.B. or 6.C.

6. E. 3. Other "technology", as follows:

a. ACOUSTICS - None

b. OPTICAL SENSORS - None

c. CAMERAS - None

OPTICS

6. E. 3. d. "Technology", as follows:

1. Optical surface coating and treatment "technology" "required" to achieve uniformity of 99.5% or better for optical coatings 500 mm or more in diameter or major axis length and with a total loss (absorption and scatter) of less than 5×10^{-3};
N.B. See also 2.E.3.f.

2. Optical fabrication "technology" using single point diamond turning techniques to produce surface finish accuracies of better than 10 nm rms on non-planar surfaces exceeding 0.5 m^2;

LASERS

6. E. 3. e. "Technology" "required" for the "development", "production" or "use" of specially designed diagnostic instruments or targets in test facilities for "SHPL" testing or testing or evaluation of materials irradiated by "SHPL" beams;

MAGNETOMETERS

6. E. 3. f. "Technology" "required" for the "development" or "production" of fluxgate "magnetometers" or fluxgate "magnetometer" systems, having any of the following:

1. A "noise level" of less than 0.05 nT rms per square root Hz at frequencies of less than 1 Hz; or

2. A "noise level" of less than 1×10^{-3} nT rms per square root Hz at frequencies of 1 Hz or more.

6. E. 3. g. GRAVIMETERS - None

6. E. 3. h. RADAR - None

Dual-Use List - Category 7 - NAVIGATIONS AND AVIONICS

7. A. SYSTEMS, EQUIPMENT AND COMPONENTS

N.B.1 *For automatic pilots for underwater vehicles, see Category 8.*
For radar, see Category 6.

7. A. 1. Linear accelerometers designed for use in inertial navigation or guidance systems and having any of the following characteristics, and specially designed components therefor:
   a. A "bias" "stability" of less (better) than 130 micro g with respect to a fixed calibration value over a period of one year;
   b. A "scale factor" "stability" of less (better) than 130 ppm with respect to a fixed calibration value over a period of one year; or
   c. Specified to function at linear acceleration levels exceeding 100 g.

   N.B. *For angular or rotational accelerometers, see 7.A.2.*

7. A. 2. Gyros, and angular or rotational accelerometers, having any of the following characteristics, and specially designed components therefor:
   a. A "drift rate" "stability", when measured in a 1 g environment over a period of three months and with respect to a fixed calibration value, of:
      1. Less (better) than 0.1° per hour when specified to function at linear acceleration levels below 10 g; or
      2. Less (better) than 0.5° per hour when specified to function at linear acceleration levels from 10 g to 100 g inclusive; or
   b. Specified to function at linear acceleration levels exceeding 100 g.

7. A. 3. Inertial navigation systems (gimballed or strapdown) and inertial equipment designed for "aircraft", land vehicle or "spacecraft" for attitude, guidance or control having any of the following characteristics, and specially designed components therefor:
   a. Navigation error (free inertial) subsequent to normal alignment of 0.8 nautical mile per hour (50% Circular Error Probable (CEP)) or less (better); or
   b. Specified to function at linear acceleration levels exceeding 10 g.

Dual-Use List - Category 7 - NAVIGATIONS AND AVIONICS

Note 1 *The parameters of 7.A.3.a. are applicable with any of the following environmental conditions:*

1. *Input random vibration with an overall magnitude of 7.7 g rms in the first half hour and a total test duration of one and one half hour per axis in each of the three perpendicular axes, when the random vibration meets the following:*
   a. *A constant power spectral density (PSD) value of 0.04 g^2/Hz over a frequency interval of 15 to 1,000 Hz; and*
   b. *The PSD attenuates with frequency from 0.04 g^2/Hz to 0.01 g^2/Hz over a frequency interval from 1,000 to 2,000 Hz; or*
2. *A roll and yaw rate of equal to or more than +2.62 radian/s (150 deg/s); or*
3. *According to national standards equivalent to 1. or 2. above.*

Note 2 *7.A.3. does not control inertial navigation systems which are certified for use on "civil aircraft" by civil authorities of a participating state.*

7. A. 4. [Deleted]

7. A. 5. Global navigation satellite systems (i.e., GPS or GLONASS) receiving equipment having any of the following characteristics, and specially designed components therefor:
   a. Employing decryption; or
   b. A null-steerable antenna.

7. A. 6. Airborne altimeters operating at frequencies other than 4.2 to 4.4 GHz inclusive, having any of the following characteristics:
   a. "Power management"; or
   b. Using phase shift key modulation.

7. A. 7. Direction finding equipment operating at frequencies above 30 MHz and having all of the following characteristics, and specially designed components therefor:
   a. "Instantaneous bandwidth" of 1 MHz or more;
   b. Parallel processing of more than 100 frequency channels; and
   c. Processing rate of more than 1,000 direction finding results per second and per frequency channel.

Dual-Use List - Category 7 - NAVIGATIONS AND AVIONICS

7. B. TEST, INSPECTION AND PRODUCTION EQUIPMENT

7. B. 1. Test, calibration or alignment equipment specially designed for equipment controlled by 7.A.

Note *7.B.1. does not control test, calibration or alignment equipment for Maintenance Level I or Maintenance Level II.*

Technical Notes

1. Maintenance Level I

The failure of an inertial navigation unit is detected on the aircraft by indications from the control and display unit (CDU) or by the status message from the corresponding sub-system. By following the manufacturer's manual, the cause of the failure may be localised at the level of the malfunctioning line replaceable unit (LRU). The operator then removes the LRU and replaces it with a spare.

2. Maintenance Level II

The defective LRU is sent to the maintenance workshop (the manufacturer's or that of the operator responsible for level II maintenance). At the maintenance workshop, the malfunctioning LRU is tested by various appropriate means to verify and localise the defective shop replaceable assembly (SRA) module responsible for the failure. This SRA is removed and replaced by an operative spare. The defective SRA (or possibly the complete LRU) is then shipped to the manufacturer. Maintenance Level II does not include the removal of controlled accelerometers or gyro sensors from the SRA.

7. B. 2. Equipment, as follows, specially designed to characterize mirrors for ring "laser" gyros:

a. Scatterometers having a measurement accuracy of 10 ppm or less (better);

b. Profilometers having a measurement accuracy of 0.5 nm (5 angstrom) or less (better).

7. B. 3. Equipment specially designed for the "production" of equipment controlled by 7.A.

Note *7.B.3 includes:*

a. Gyro tuning test stations;

b. Gyro dynamic balance stations;

c. Gyro run-in/motor test stations;

d. Gyro evacuation and fill stations;

e. Centrifuge fixtures for gyro bearings;

f. Accelerometer axis align stations.

7. C. MATERIALS - None

Dual-Use List - Category 7 - NAVIGATIONS AND AVIONICS

7. D. SOFTWARE

7. D. 1. "Software" specially designed or modified for the "development" or "production" of equipment controlled by 7.A. or 7.B.

2. "Source code" for the "use" of any inertial navigation equipment, including inertial equipment not controlled by 7.A.3. or 7.A.4., or Attitude and Heading Reference Systems (AHRS).
Note *7.D.2. does not control "source code" for the "use" of gimballed AHRS*

Technical Note
AHRS generally differ from inertial navigation systems (INS) in that an AHRS provides attitude and heading information and normally does not provide the acceleration, velocity and position information associated with an INS.

3. Other "software", as follows:

a. "Software" specially designed or modified to improve the operational performance or reduce the navigational error of systems to the levels specified in 7.A.3. or 7.A.4.;

b. "Source code" for hybrid integrated systems which improves the operational performance or reduces the navigational error of systems to the level specified in 7.A.3. by continuously combining inertial data with any of the following navigation data:
1. Doppler radar velocity;
2. Global navigation satellite systems (i.e., GPS or GLONASS) reference data; or
3. Terrain data from databases;

c. "Source code" for integrated avionics or mission systems which combine sensor data and employ "expert systems";

d. "Source code" for the "development" of any of the following:
1. Digital flight management systems for "total control of flight";
2. Integrated propulsion and flight control systems;
3. Fly-by-wire or fly-by-light control systems;
4. Fault-tolerant or self-reconfiguring "active flight control systems";
5. Airborne automatic direction finding equipment;
6. Air data systems based on surface static data; or
7. Raster-type head-up displays or three dimensional displays;

e. Computer-aided-design (CAD) "software" specially designed for the "development" of "active flight control systems", helicopter multi-axis fly-by-wire or fly-by-light controllers or helicopter "circulation controlled anti-torque or circulation-controlled direction control systems" whose "technology" is controlled in 7.E.4.b., 7.E.4.c.1. or 7.E.4.c.2.

Dual-Use List - Category 7 - NAVIGATIONS AND AVIONICS

7. E. TECHNOLOGY

1. "Technology" according to the General Technology Note for the "development" of equipment or "software" controlled by 7.A., 7.B. or 7.D.

2. "Technology" according to the General Technology Note for the "production" of equipment controlled by 7.A. or 7.B.

3. "Technology" according to the General Technology Note for the repair, refurbishing or overhaul of equipment controlled by 7.A.1. to 7.A.4.

Note *7.E.3. does not control maintenance "technology" directly associated with calibration, removal or replacement of damaged or unserviceable LRUs and SRAs of a "civil aircraft" as described in Maintenance Level I or Maintenance Level II.*

N.B. *See Technical Notes to 7.B.1.*

7. E. 4. Other "technology", as follows:

a. "Technology" for the "development" or "production" of:

1. Airborne automatic direction finding equipment operating at frequencies exceeding 5 MHz;
2. Air data systems based on surface static data only, i.e., which dispense with conventional air data probes;
3. Raster-type head-up displays or three dimensional displays for "aircraft";
4. Inertial navigation systems or gyro-astro compasses containing accelerometers or gyros controlled by 7.A.1. or 7.A.2.;
5. Electric actuators (i.e., electromechanical, electrohydrostatic and integrated actuator package) specially designed for "primary flight control";
6. "Flight control optical sensor array" specially designed for implementing "active flight control systems";

7. E. 4. b. "Development" "technology", as follows, for "active flight control systems" (including fly-by-wire or fly-by-light):

1. Configuration design for interconnecting multiple microelectronic processing elements (on-board computers) to achieve "real time processing" for control law implementation;
2. Control law compensation for sensor location or dynamic airframe loads, i.e., compensation for sensor vibration environment or for variation of sensor location from the centre of gravity;
3. Electronic management of data redundancy or systems redundancy for fault detection, fault tolerance, fault isolation or reconfiguration;

Note *7.E.4.b.3. does not control "technology" for the design of physical redundancy.*

Dual-Use List - Category 7 - NAVIGATIONS AND AVIONICS

7. E. 4. b. 4. Flight controls which permit inflight reconfiguration of force and moment controls for real time autonomous air vehicle control;

5. Integration of digital flight control, navigation and propulsion control data into a digital flight management system for "total control of flight";

Note *7.E.4.b.5. does not control:*

1. "Development" "technology" for integration of digital flight control, navigation and propulsion control data into a digital flight management system for "flight path optimisation";

2. "Development" "technology" for "aircraft" flight instrument systems integrated solely for VOR, DME, ILS or MLS navigation or approaches.

6. Full authority digital flight control or multisensor mission management systems employing "expert systems";

N.B. *For "technology" for Full Authority Digital Engine Control ("FADEC"), see 9.E.3.a.9.*

7. E. 4. c. "Technology" for the "development" of helicopter systems, as follows:

1. Multi-axis fly-by-wire or fly-by-light controllers which combine the functions of at least two of the following into one controlling element:
   a. Collective controls;
   b. Cyclic controls;
   c. Yaw controls;
2. "Circulation-controlled anti-torque or circulation-controlled directional control systems";
3. Rotor blades incorporating "variable geometry airfoils" for use in systems using individual blade control.

Dual-Use List - Category 8 - MARINE

8. A. SYSTEMS, EQUIPMENT AND COMPONENTS

8. A. 1. Submersible vehicles and surface vessels, as follows:

N.B. For the control status of equipment for submersible vehicles, see:
Category 5, Part 2 "Information Security" for encrypted communication equipment;
Category 6 for sensors;
Categories 7 and 8 for navigation equipment;
Category 8.A. for underwater equipment.

8. A. 1. a. Manned, tethered submersible vehicles designed to operate at depths exceeding 1,000 m;

8. A. 1. b. Manned, untethered submersible vehicles, having any of the following:

1. Designed to operate autonomously and having a lifting capacity of all the following:
   a. 10% or more of their weight in air; and
   b. 15 kN or more;

2. Designed to operate at depths exceeding 1,000 m; or

3. Having all of the following:
   a. Designed to carry a crew of 4 or more;
   b. Designed to operate autonomously for 10 hours or more;
   c. Having a range of 25 nautical miles or more; and
   d. Having a length of 21 m or less;

Technical Notes

1. For the purposes of 8.A.1.b., operate autonomously means fully submerged, without snorkel, all systems working and cruising at minimum speed at which the submersible can safely control its depth dynamically by using its depth planes only, with no need for a support vessel or support base on the surface, sea-bed or shore, and containing a propulsion system for submerged or surface use.

2. For the purposes of 8.A.1.b., range means half the maximum distance a submersible vehicle can cover.

8. A. 1. c. Unmanned, tethered submersible vehicles designed to operate at depths exceeding 1,000 m, having any of the following:

1. Designed for self-propelled manoeuvre using propulsion motors or thrusters controlled by 8.A.2.a.2.; or
2. Having a fibre optic data link;

Dual-Use List - Category 8 - MARINE

8. A. 1. d. Unmanned, untethered submersible vehicles, having any of the following:

1. Designed for deciding a course relative to any geographical reference without real-time human assistance;
2. Having an acoustic data or command link; or
3. Having a fibre optic data or command link exceeding 1,000 m;

8. A. 1. e. Ocean salvage systems with a lifting capacity exceeding 5 MN for salvaging objects from depths exceeding 250 m and having any of the following:

1. Dynamic positioning systems capable of position keeping within 20 m of a given point provided by the navigation system; or
2. Seafloor navigation and navigation integration systems for depths exceeding 1,000 m with positioning accuracies to within 10 m of a predetermined point;

8. A. 1. f. Surface-effect vehicles (fully skirted variety) having all of the following characteristics:

1. a maximum design speed, fully loaded, exceeding 30 knots in a significant wave height of 1.25 m (Sea State 3) or more;
2. a cushion pressure exceeding 3,830 Pa; and
3. a light-ship-to-full-load displacement ratio of less than 0.70;

8. A. 1. g. Surface-effect vehicles (rigid sidewalls) with a maximum design speed, fully loaded, exceeding 40 knots in a significant wave height of 3.25 m (Sea State 5) or more;

8. A. 1. h. Hydrofoil vessels with active systems for automatically controlling foil systems, with a maximum design speed, fully loaded, of 40 knots or more in a significant wave height of 3.25 m (Sea State 5) or more;

8. A. 1. i. Small waterplane area vessels having any of the following:

1. A full load displacement exceeding 500 tonnes with a maximum design speed, fully loaded, exceeding 35 knots in a significant wave height of 3.25 m (Sea State 5) or more; or
2. A full load displacement exceeding 1,500 tonnes with a maximum design speed, fully loaded, exceeding 25 knots in a significant wave height of 4 m (Sea State 6) or more.

Technical Note

A small waterplane area vessel is defined by the following formula: waterplane area at an operational design draft less than 2x (displaced volume at the operational design draft).[2,3]

Dual-Use List - Category 8 - MARINE

8. A. 2. Systems and equipment, as follows:
N.B. For underwater communications systems, see Category 5, Part 1 -Telecommunications.

8. A. 2. a. Systems and equipment, specially designed or modified for submersible vehicles, designed to operate at depths exceeding 1,000 m, as follows:
1. Pressure housings or pressure hulls with a maximum inside chamber diameter exceeding 1.5 m;
2. Direct current propulsion motors or thrusters;
3. Umbilical cables, and connectors therefor, using optical fibre and having synthetic strength members;

8. A. 2. b. Systems specially designed or modified for the automated control of the motion of submersible vehicles controlled by 8.A.1. using navigation data and having closed loop servo-controls:
1. Enabling a vehicle to move within 10 m of a predetermined point in the water column;
2. Maintaining the position of the vehicle within 10 m of a predetermined point in the water column; or
3. Maintaining the position of the vehicle within 10 m while following a cable on or under the seabed;

8. A. 2. c. Fibre optic hull penetrators or connectors;

8. A. 2. d. Underwater vision systems, as follows:
1. Television systems and television cameras, as follows:
a. Television systems (comprising camera, monitoring and signal transmission equipment) having a limiting resolution when measured in air of more than 800 lines and specially designed or modified for remote operation with a submersible vehicle;
b. Underwater television cameras having a limiting resolution when measured in air of more than 1,100 lines;
c. Low light level television cameras specially designed or modified for underwater use containing all of the following:
1. Image intensifier tubes controlled by 6.A.2.a.2.a.; and
2. More than 150,000 "active pixels" per solid state area array;

Technical Note
Limiting resolution in television is a measure of horizontal resolution usually expressed in terms of the maximum number of lines per picture height discriminated on a test chart, using IEEE Standard 208/1960 or any equivalent standard.

8. A. 2. d. 2. Systems, specially designed or modified for remote operation with an underwater vehicle, employing techniques to minimise the effects of back scatter, including range-gated illuminators or "laser" systems;

8. A. 2. e. Photographic still cameras specially designed or modified for underwater use below 150 m having a film format of 35 mm or larger, and having any of the following:

1. Annotation of the film with data provided by a source external to the camera;

Dual-Use List - Category 8 - MARINE

2. Automatic back focal distance correction; or
3. Automatic compensation control specially designed to permit an underwater camera housing to be usable at depths exceeding 1,000 m;

8. A. 2. f. Electronic imaging systems, specially designed or modified for underwater use, capable of storing digitally more than 50 exposed images;

8. A. 2. g. Light systems, as follows, specially designed or modified for underwater use:

1. Stroboscopic light systems capable of a light output energy of more than 300 J per flash and a flash rate of more than 5 flashes per second;
2. Argon arc light systems specially designed for use below 1,000 m;

8. A. 2. h. "Robots" specially designed for underwater use, controlled by using a dedicated "stored programme controlled" computer, having any of the following:

1. Systems that control the "robot" using information from sensors which measure force or torque applied to an external object, distance to an external object, or tactile sense between the "robot" and an external object; or
2. The ability to exert a force of 250 N or more or a torque of 250 Nm or more and using titanium based alloys or "fibrous or filamentary" "composite" materials in their structural members;

8. A. 2. i. Remotely controlled articulated manipulators specially designed or modified for use with submersible vehicles, having any of the following:

1. Systems which control the manipulator using the information from sensors which measure the torque or force applied to an external object, or tactile sense between the manipulator and an external object; or
2. Controlled by proportional master-slave techniques or by using a dedicated "stored programme controlled" computer, and having 5 degrees of freedom of movement or more;

Note *Only functions having proportional control using positional feedback or by using a dedicated "stored programme controlled" computer are counted when determining the number of degrees of freedom of movement.*

Dual-Use List - Category 8 - MARINE

8. A. 2. j. Air independent power systems, specially designed for underwater use, as follows:

1. Brayton or Rankine cycle engine air independent power systems having any of the following:
   a. Chemical scrubber or absorber systems specially designed to remove carbon dioxide, carbon monoxide and particulates from recirculated engine exhaust;
   b. Systems specially designed to use a monoatomic gas;
   c. Devices or enclosures specially designed for underwater noise reduction in frequencies below 10 kHz, or special mounting devices for shock mitigation; or
   d. Systems specially designed:
      1. To pressurise the products of reaction or for fuel reformation;
      2. To store the products of the reaction; and
      3. To discharge the products of the reaction against a pressure of 100 kPa or more;

8. A. 2. j. 2. Diesel cycle engine air independent systems, having all of the following:
   a. Chemical scrubber or absorber systems specially designed to remove carbon dioxide, carbon monoxide and particulates from recirculated engine exhaust;
   b. Systems specially designed to use a monoatomic gas;
   c. Devices or enclosures specially designed for underwater noise reduction in frequencies below 10 kHz or special mounting devices for shock mitigation; and
   d. Specially designed exhaust systems that do not exhaust continuously the products of combustion;

8. A. 2. j. 3. Fuel cell air independent power systems with an output exceeding 2 kW having any of the following:
   a. Devices or enclosures specially designed for underwater noise reduction in frequencies below 10 kHz or special mounting devices for shock mitigation; or
   b. Systems specially designed:
      1. To pressurise the products of reaction or for fuel reformation;
      2. To store the products of the reaction; and
      3. To discharge the products of the reaction against a pressure of 100 kPa or more;

Dual-Use List - Category 8 - MARINE

8. A. 2. j. 4. Stirling cycle engine air independent power systems, having all of the following:
   a. Devices or enclosures specially designed for underwater noise reduction in frequencies below 10 kHz or special mounting devices for shock mitigation; and
   b. Specially designed exhaust systems which discharge the products of combustion against a pressure of 100 kPa or more;

8. A. 2. k. Skirts, seals and fingers, having any of the following:

   1. Designed for cushion pressures of 3,830 Pa or more, operating in a significant wave height of 1.25 m (Sea State 3) or more and specially designed for surface effect vehicles (fully skirted variety) controlled by 8.A.1.f.; or

   2. Designed for cushion pressures of 6,224 Pa or more, operating in a significant wave height of 3.25 m (Sea State 5) or more and specially designed for surface effect vehicles (rigid sidewalls) controlled by 8.A. 1.g.;

8. A. 2. l. Lift fans rated at more than 400 kW specially designed for surface effect vehicles controlled by 8.A.1.f. or 8.A.1.g.;

8. A. 2. m. Fully submerged subcavitating or supercavitating hydrofoils specially designed for vessels controlled by 8.A.1.h.;

8. A. 2. n. Active systems specially designed or modified to control automatically the sea-induced motion of vehicles or vessels controlled by 8.A.1.f., 8.A.1.g., 8.A.1.h. or 8.A.1.i.;

8. A. 2. o. Propellers, power transmission systems, power generation systems and noise reduction systems, as follows:
   1. Water-screw propeller or power transmission systems, as follows, specially designed for surface effect vehicles (fully skirted or rigid sidewall variety), hydrofoils or small waterplane area vessels controlled by 8.A.1.f., 8. A. 1. g., 8.A.1.h. or 8.A.1.i.:
      a. Supercavitating, super-ventilated, partially-submerged or surface piercing propellers rated at more than 7.5 MW;
      b. Contrarotating propeller systems rated at more than 15 MW;
      c. Systems employing pre-swirl or post-swirl techniques for smoothing the flow into a propeller;
      d. Light-weight, high capacity (K factor exceeding 300) reduction gearing;
      e. Power transmission shaft systems, incorporating "composite" material components, capable of transmitting more than 1 MW;

Dual-Use List - Category 8 - MARINE

8. A. 2. o. 2. Water-screw propeller, power generation systems or transmission systems designed for use on vessels, as follows:
   a. Controllable-pitch propellers and hub assemblies rated at more than 30 MW;
   b. Internally liquid-cooled electric propulsion engines with a power output exceeding 2.5 MW;
   c. "Superconductive" propulsion engines, or permanent magnet electric propulsion engines, with a power output exceeding 0.1 MW;
   d. Power transmission shaft systems, incorporating "composite" material components, capable of transmitting more than 2 MW;
   e. Ventilated or base-ventilated propeller systems rated at more than 2.5 MW;

8. A. 2. o. 3. Noise reduction systems designed for use on vessels of 1,000 tonnes displacement or more, as follows:
   a. Systems that attenuate underwater noise at frequencies below 500 Hz and consist of compound acoustic mounts for the acoustic isolation of diesel engines, diesel generator sets, gas turbines, gas turbine generator sets, propulsion motors or propulsion reduction gears, specially designed for sound or vibration isolation, having an intermediate mass exceeding 30% of the equipment to be mounted;
   b. Active noise reduction or cancellation systems, or magnetic bearings, specially designed for power transmission systems, and incorporating electronic control systems capable of actively reducing equipment vibration by the generation of anti-noise or anti-vibration signals directly to the source;

8. A. 2. p. Pumpjet propulsion systems having a power output exceeding 2.5 MW using divergent nozzle and flow conditioning vane techniques to improve propulsive efficiency or reduce propulsion-generated underwater-radiated noise;

8. A. 2. q. Self-contained, closed or semi-closed circuit (rebreathing) diving and underwater swimming apparatus.
   Note *8.A.2.q. does not control an individual apparatus for personal use when accompanying its user.*

8. B. TEST, INSPECTION AND PRODUCTION EQUIPMENT

8. B. 1. Water tunnels, having a background noise of less than 100 dB (reference 1 µPa, 1 Hz) in the frequency range from 0 to 500 Hz, designed for measuring acoustic fields generated by a hydro-flow around propulsion system models.

Dual-Use List - Category 8 - MARINE

8. C. MATERIALS

8. C. 1. Syntactic foam designed for underwater use, having all of the following:
   a. Designed for marine depths exceeding 1,000 m; and
   b. A density less than 561 kg/m^3.

   Technical Note
   Syntactic foam consists of hollow spheres of plastic or glass embedded in a resin matrix.

8. D. SOFTWARE

8. D. 1. "Software" specially designed or modified for the "development", "production" or "use" of equipment or materials controlled by 8.A., 8.B. or 8.C.

8. D. 2. Specific "software" specially designed or modified for the "development", "production", repair, overhaul or refurbishing (re-machining) of propellers specially designed for underwater noise reduction.

8. E. TECHNOLOGY

8. E. 1. "Technology" according to the General Technology Note for the "development" or "production" of equipment or materials controlled by 8.A., 8.B. or 8.C.

8. E. 2. Other "technology", as follows:
   a. "Technology" for the "development", "production", repair, overhaul or refurbishing (re-machining) of propellers specially designed for underwater noise reduction;
   b. "Technology" for the overhaul or refurbishing of equipment controlled by 8.A.1., 8.A.2.b., 8.A.2.j., 8.A.2.o. or 8.A.2.p.

Dual-Use List - Category 9 - PROPULSION

9. A. SYSTEMS, EQUIPMENT AND COMPONENTS

9. A. 1. Aero gas turbine engines incorporating any of the "technologies" controlled by 9.E.3.a., as follows:
   a. Not certified for the specific "civil aircraft" for which they are intended;
      Note *For the purpose of the "civil aircraft" certification process, a number of up to 16 civil certified engines, assemblies or components including spares, is considered appropriate.*
   b. Not certified for civil use by the aviation authorities in a participating state;
   c. Designed to cruise at speeds exceeding Mach 1.2 for more than thirty minutes.

9. A. 2. Marine gas turbine engines with an ISO standard continuous power rating of 24,245 kW or more and a specific fuel consumption not exceeding 0.219 kg/kWh in the power range from 35 to 100%, and specially designed assemblies and components therefor.
   Note *The term 'marine gas turbine engines' includes those industrial, or aero-derivative, gas turbine engines adapted for a ship's electric power generation or propulsion.*

9. A. 3. Specially designed assemblies and components, incorporating any of the "technologies" controlled by 9.E.3.a., for the following gas turbine engine propulsion systems:
   a. Controlled by 9.A.1.;
   b. Whose design or production origins are either non-participating states or unknown to the manufacturer.

9. A. 4. Space launch vehicles and "spacecraft".
   Note *9.A.4. does not control payloads.*
      N.B. *For the control status of products contained in "spacecraft "payloads, see the appropriate Categories.*

9. A. 5. Liquid rocket propulsion systems containing any of the systems or components controlled by 9.A.6.

9. A. 6. Systems and components specially designed for liquid rocket propulsion systems, as follows:
   a. Cryogenic refrigerators, flightweight dewars, cryogenic heat pipes or cryogenic systems specially designed for use in space vehicles and capable of restricting cryogenic fluid losses to less than 30% per year;

Dual-Use List - Category 9 - PROPULSION

9. A. 6. b. Cryogenic containers or closed-cycle refrigeration systems capable of providing temperatures of 100 K (-173° C) or less for "aircraft" capable of sustained flight at speeds exceeding Mach 3, launch vehicles or "spacecraft";
   c. Slush hydrogen storage or transfer systems;
   d. High pressure (exceeding 17.5 MPa) turbo pumps, pump components or their associated gas generator or expander cycle turbine drive systems;
   e. High-pressure (exceeding 10.6 MPa) thrust chambers and nozzles therefor;
   f. Propellant storage systems using the principle of capillary containment or positive expulsion (i.e., with flexible bladders);
   g. Liquid propellant injectors, with individual orifices of 0.381 mm or smaller in diameter (an area of 1.14×10^{-3} cm^2 or smaller for non-circular orifices) specially designed for liquid rocket engines;
   h. One-piece carbon-carbon thrust chambers or one-piece carbon-carbon exit cones with densities exceeding 1.4 g/cm^3 and tensile strengths exceeding 48 MPa.

9. A. 7. Solid rocket propulsion systems with any of the following:
   a. Total impulse capacity exceeding 1.1 MNs;
   b. Specific impulse of 2.4 kNs/kg or more when the nozzle flow is expanded to ambient sea level conditions for an adjusted chamber pressure of 7 MPa;
   c. Stage mass fractions exceeding 88% and propellant solid loadings exceeding 86%;
   d. Any of the components controlled by 9.A.8.; or
   e. Insulation and propellant bonding systems using direct-bonded motor designs to provide a strong mechanical bond or a barrier to chemical migration between the solid propellant and case insulation material.
   Technical Note
   For the purposes of 9.A.7.e , a strong mechanical bond means bond strength equal to or more than propellant strength.

9. A. 8. Components, as follows, specially designed for solid rocket propulsion systems:
   a. Insulation and propellant bonding systems using liners to provide a strong mechanical bond or a barrier to chemical migration between the solid propellant and case insulation material;
   Technical Note
   For the purposes of 9.A.8.a., a strong mechanical bond means bond strength equal to or more than propellant strength.
   b. Filament-wound "composite" motor cases exceeding 0.61 m in diameter or having structural efficiency ratios (PV/W) exceeding 25 km.
   Technical Note
   The structural efficiency ratio (PV/W) is the burst pressure (P) multiplied by the vessel volume (V) divided by the total pressure vessel weight (W).
   c. Nozzles with thrust levels exceeding 45 kN or nozzle throat erosion rates of less than 0.075 mm/s;
   d. Movable nozzle or secondary fluid injection thrust vector control systems capable of any of the following:
      1. Omni-axial movement exceeding ±5°;
      2. Angular vector rotations of 20°/s or more; or
      3. Angular vector accelerations of $40°/s^2$ or more.

Dual-Use List - Category 9 - PROPULSION

9. A. 9. Hybrid rocket propulsion systems with:
   a. Total impulse capacity exceeding 1.1 MNs; or
   b. Thrust levels exceeding 220 kN in vacuum exit conditions.

9. A. 10. Specially designed components, systems and structures for launch vehicles, launch vehicle propulsion systems or "spacecraft", as follows:
   a. Components and structures each exceeding 10 kg, specially designed for launch vehicles manufactured using metal "matrix", "composite", organic "composite", ceramic "matrix" or intermetallic reinforced materials controlled by 1.C.7. or 1.C.10.;
      Note *The weight cut-off is not relevant for nose cones.*
   b. Components and structures specially designed for launch vehicle propulsion systems controlled by 9.A.5. to 9.A.9. manufactured using metal matrix, composite, organic composite, ceramic matrix or intermetallic reinforced materials controlled by 1.C.7. or 1.C.10.;
   c. Structural components and isolation systems specially designed to control actively the dynamic response or distortion of "spacecraft" structures;
   d. Pulsed liquid rocket engines with thrust-to-weight ratios equal to or more than 1 kN/kg and a response time (the time required to achieve 90% of total rated thrust from start-up) of less than 30 ms.

9. A. 11. Ramjet, scramjet or combined cycle engines and specially designed components therefor.

9. B. TEST, INSPECTION AND PRODUCTION EQUIPMENT

9. B. 1. Specially designed equipment, tooling and fixtures, as follows, for manufacturing gas turbine blades, vanes or tip shroud castings:
   a. Directional solidification or single crystal casting equipment;
   b. Ceramic cores or shells.

9. B. 2. On-line (real time) control systems, instrumentation (including sensors) or automated data acquisition and processing equipment, specially designed for the "development" of gas turbine engines, assemblies or components incorporating "technologies" controlled by 9.E.3.a.

9. B. 3. Equipment specially designed for the "production" or test of gas turbine brush seals designed to operate at tip speeds exceeding 335 m/s, and temperatures in excess of 773 K (500° C), and specially designed components or accessories therefor.

9. B. 4. Tools, dies or fixtures for the solid state joining of "superalloy", titanium or intermetallic airfoil-to-disk combinations described in 9.E.3.a.3. or 9.E.3.a.6. for gas turbines.

Dual-Use List - Category 9 - PROPULSION

9. B. 5. On-line (real time) control systems, instrumentation (including sensors) or automated data acquisition and processing equipment, specially designed for use with any of the following wind tunnels or devices:
   a. [Deleted]
   b. Devices for simulating flow-environments at speeds exceeding Mach 5, including hot-shot tunnels, plasma arc tunnels, shock tubes, shock tunnels, gas tunnels and light gas guns; or
   c. Wind tunnels or devices, other than two-dimensional sections, capable of simulating Reynolds number flows exceeding 25 x 10^6.

9. B. 6. Acoustic vibration test equipment capable of producing sound pressure levels of 160 dB or more (referenced to 20 μPa) with a rated output of 4 kW or more at a test cell temperature exceeding 1,273 K (1,000° C), and specially designed quartz heaters therefor.

9. B. 7. Equipment specially designed for inspecting the integrity of rocket motors using non-destructive test (NDT) techniques other than planar X-ray or basic physical or chemical analysis.

9. B. 8. Transducers specially designed for the direct measurement of the wall skin friction of the test flow with a stagnation temperature exceeding 833 K (560° C).

9. B. 9. Tooling specially designed for producing turbine engine powder metallurgy rotor components capable of operating at stress levels of 60% of ultimate tensile strength (UTS) or more and metal temperatures of 873 K (600° C) or more.

9. C. MATERIALS - None

9. D. SOFTWARE

9. D. 1. "Software" specially designed or modified for the "development" of equipment or "technology" controlled by 9.A., 9.B. or 9.E.3.

9. D. 2. "Software" specially designed or modified for the "production" of equipment controlled by 9.A. or 9.B.

9. D. 3. "Software" specially designed or modified for the "use" of full authority digital electronic engine controls (FADEC) for propulsion systems controlled by 9.A. or equipment controlled by 9.B., as follows:
   a. "Software" in digital electronic controls for propulsion systems, aerospace test facilities or air breathing aero-engine test facilities;
   b. Fault-tolerant "software" used in "FADEC" systems for propulsion systems and associated test facilities.

9. D. 4. Other "software", as follows:

a. 2D or 3D viscous "software" validated with wind tunnel or flight test data required for detailed engine flow modelling;

b. "Software" for testing aero gas turbine engines, assemblies or components, specially designed to collect, reduce and analyse data in real time, and capable of feedback control, including the dynamic adjustment of test articles or test conditions, as the test is in progress;

c. "Software" specially designed to control directional solidification or single crystal casting;

d. "Software" in "source code", "object code" or machine code required for the "use" of active compensating systems for rotor blade tip clearance control.

Note *9.D.4.d. does not control "software" embedded in uncontrolled equipment or required for maintenance activities associated with the calibration or repair or updates to the active compensating clearance control system.*

9. E. TECHNOLOGY

9. E. 1. "Technology" according to the General Technology Note for the "development" of equipment or "software" controlled by 9.A.1.c., 9.A.4. to 9.A.11., 9.B. or 9.D.

9. E. 2. "Technology" according to the General Technology Note for the "production" of equipment controlled by 9.A.1.c., 9.A.4. to 9.A.11. or 9.B.

N.B. *For "technology" for the repair of controlled structures, laminates or materials, see 1.E.2.f.*

Note *"Development" or "production" "technology" controlled by 9.E. for gas turbine engines remains controlled when used as "use" "technology" for repair, rebuild and overhaul. Excluded from control are: technical data, drawings or documentation for maintenance activities directly associated with calibration, removal or replacement of damaged or unserviceable line replaceable units, including replacement of whole engines or engine modules.*

9. E. 3. Other "technology", as follows:

a. "Technology" "required" for the "development" or "production" of any of the following gas turbine engine components or systems:

1. Gas turbine blades, vanes or tip shrouds made from directionally solidified (DS) or single crystal (SC) alloys having (in the 001 Miller Index Direction) a stress-rupture life exceeding 400 hours at 1,273 K (1,000° C) at a stress of 200 MPa, based on the average property values;

2. Multiple domed combustors operating at average burner outlet temperatures exceeding 1,813 K (1,540° C) or combustors incorporating thermally decoupled combustion liners, non-metallic liners or non-metallic shells;

Dual-Use List - Category 9 - PROPULSION

9. E. 3. a. 3. Components manufactured from any of the following:
   a. Organic "composite" materials designed to operate above 588 K (315° C);
   b. Metal "matrix" "composite", ceramic "matrix", intermetallic or intermetallic reinforced materials controlled by 1.C.7.; or
   c. "Composite" material controlled by 1.C.10. and manufactured with resins controlled by 1.C.8.

4. Uncooled turbine blades, vanes, tip-shrouds or other components designed to operate at gas path temperatures of 1,323 K (1,050° C) or more;

5. Cooled turbine blades, vanes or tip-shrouds, other than those described in 9.E.3.a.1., exposed to gas path temperatures of 1,643 K (1,370° C) or more;

6. Airfoil-to-disk blade combinations using solid state joining;

7. Gas turbine engine components using "diffusion bonding" "technology" controlled by 2.E.3.b.;

8. Damage tolerant gas turbine engine rotating components using powder metallurgy materials controlled by 1.C.2.b.;

9. "FADEC" for gas turbine and combined cycle engines and their related diagnostic components, sensors and specially designed component;

10. Adjustable flow path geometry and associated control systems for:
    a. Gas generator turbines;
    b. Fan or power turbines;
    c. Propelling nozzles; or

    Note 1 *Adjustable flow path geometry and associated control systems in 9.E.3.a.10. do not include inlet guide vanes, variable pitch fans, variable stators or bleed valves for compressors.*

    Note 2 *9.E.3.a.10. does not control "development" or "production" "technology" for adjustable flow path geometry for reverse thrust.*

11. Wide chord hollow fan blades without part-span support.

9. E. 3. b. "Technology" "required" for the "development" or "production" of any of the following:
   1. Wind tunnel aero-models equipped with non-intrusive sensors capable of transmitting data from the sensors to the data acquisition system; or
   2. "Composite" propeller blades or propfans capable of absorbing more than 2,000 kW at flight speeds exceeding Mach 0.55;

Dual-Use List - Category 9 - PROPULSION

9. E. 3. c. "Technology" "required" for the "development" or "production" of gas turbine engine components using "laser", water jet, ECM or EDM hole drilling processes to produce holes having any of the following sets of characteristics:

1. All of the following:
   a. Depths more than four times their diameter;
   b. Diameters less than 0.76 mm; and
   c. Incidence angles equal to or less than 25°; or
2. All of the following:
   a. Depths more than five times their diameter;
   b. Diameters less than 0.4 mm; and
   c. Incidence angles of more than 25°;

Technical Note

For the purposes of 9.E.3.c., incidence angle is measured from a plane tangential to the airfoil surface at the point where the hole axis enters the airfoil surface.

9. E. 3. d. "Technology" "required" for the "development" or "production" of helicopter power transfer systems or tilt rotor or tilt wing "aircraft" power transfer systems;

9. E. 3. e. "Technology" for the "development" or "production" of reciprocating diesel engine ground vehicle propulsion systems having all of the following:

1. A box volume of 1.2 m^3 or less;
2. An overall power output of more than 750 kW based on 80/1269/EEC, ISO 2534 or national equivalents; and
3. A power density of more than 700 kW/m^3 of box volume;

Technical Note

Box volume: the product of three perpendicular dimensions is measured in the following way:

Length: The length of the crankshaft from front flange to flywheel face;

Width: The widest of the following:
- *a. The outside dimension from valve cover to valve cover;*
- *b. The dimensions of the outside edges of the cylinder heads; or*
- *c. The diameter of the flywheel housing;*

Height: The largest of the following:
- *a. The dimension of the crankshaft centre-line to the top plane of the valve cover (or cylinder head) plus twice the stroke; or*
- *b. The diameter of the flywheel housing.*

Dual-Use List - Category 9 - PROPULSION

9. E. 3. f. "Technology" "required" for the "production" of specially designed components, as follows, for high output diesel engines:
   1. "Technology" "required" for the "production" of engine systems having all of the following components employing ceramics materials controlled by 1.C.7:
      a. Cylinder liners;
      b. Pistons;
      c. Cylinder heads; and
      d. One or more other components (including exhaust ports, turbochargers, valve guides, valve assemblies or insulated fuel injectors);

9. E. 3. f. 2. "Technology" "required" for the "production" of turbocharger systems, with single-stage compressors having all of the following:
   a. Operating at pressure ratios of 4:1 or higher;
   b. A mass flow in the range from 30 to 130 kg per minute; and
   c. Variable flow area capability within the compressor or turbine sections;

9. E. 3. f. 3. "Technology" "required" for the "production" of fuel injection systems with a specially designed multifuel (e.g., diesel or jet fuel) capability covering a viscosity range from diesel fuel (2.5 cSt at 310.8 K (37.8° C)) down to gasoline fuel (0.5 cSt at 310.8 K (37.8° C)), having both of the following:

   a. Injection amount in excess of 230 mm3 per injection per cylinder; and
   b. Specially designed electronic control features for switching governor characteristics automatically depending on fuel property to provide the same torque characteristics by using the appropriate sensors;

9. E. 3. g. "Technology" "required" for the "development" or "production" of high output diesel engines for solid, gas phase or liquid film (or combinations thereof) cylinder wall lubrication, permitting operation to temperatures exceeding 723 K (450° C), measured on the cylinder wall at the top limit of travel of the top ring of the piston.

Technical Note

High output diesel engines: diesel engines with a specified brake mean effective pressure of 1.8 MPa or more at a speed of 2,300 r.p.m., provided the rated speed is 2,300 r.p.m. or more.

Dual-Use List - ANNEX 1

ANNEX 1 OF THE LIST OF DUAL-USE GOODS AND TECHNOLOGIES

Note *This Annex contains a sub-set of the Items controlled by the List of Dual-Use Goods and Technologies.*

N.B. *Where abbreviated entries are used, see List of Dual-Use Goods and Technologies for full details. Text that differs from that in the List of Dual-Use Goods and Technologies is* ***shaded****.*

Category 1

1.A.2.	"Composite" structures or laminates ...
1.C.1.	Materials specially designed for use as absorbers of electromagnetic waves ...
1.C.7.c. & 1.C.7.d.	Ceramic-ceramic "composite" materials ...
1.C.10.c. & 1.C.10.d.	Fibrous or filamentary materials ...
1.C.12.	Materials as follows ...
1.D.2.	"Software" for the "development" of organic "matrix", metal "matrix" or carbon "matrix" laminates or "composites" **listed on this Annex**.
1.E.1.	"Technology" according to the General Technology Note for the "development" or "production" of equipment and materials in **1.A.2. or 1.C. of this Annex**.
1.E.2.e. & 1.E.2.f.	Other "technology" ...

Category 2*

2.B.1.a. Machine tools for turning, having all of the following characteristics:

1. Positioning accuracy with "all compensations available" equal to or less (better) than **3.6 µm** according to ISO 230/2 (1997) or national equivalents along any linear axis; and
2. Two or more axes which can be coordinated simultaneously for "contouring control".

2.B.1.b. Machine tools for milling, having any of the following characteristics:

1.a. Positioning accuracy with "all compensations available" equal to or less (better) than **3.6 µm** according to ISO 230/2 (1997) or national equivalents along any linear axis; and

b. Three linear axes plus one rotary axis which can be coordinated simultaneously for "contouring control"; or

* Italy and Switzerland reserve the right to notify only denials on machine-tools in 2.B.1.a. and 2.B.1.b. of this Annex.

Dual-Use List - ANNEX 1

Category 2 (contd.)

2.B.1.b. 2. Five or more axes which can be coordinated simultaneously for "contouring control" **and have a positioning accuracy with "all compensations available" equal to or less (better) than 3.6 µm according to ISO 230/2 (1997) or national equivalents along any linear axis;** or

3. A positioning accuracy for jig boring machines, with "all compensations available", equal to or less (better) than 3 µm according to ISO 230/2 (1997) or national equivalents along any linear axis;

2.B.1.d. Electrical discharge machines (EDM) ...

2.B.1.f. Deep-hole-drilling machines ...

2.B.3. "Numerically controlled" or manual machine tools ...

2.D.1. **"Software", other than that controlled by 2.D.2., specially designed for the "development" or "production" of equipment in 2.B. of this Annex.**

2.E.1. **"Technology" according to the General Technology Note for the "development" of equipment or "software" in 2.B. or 2.D. of this Annex.**

2.E.2. "Technology" according to the General Technology Note for the "production" of equipment in 2.B. **of this Annex**.

Category 3

3.A.2.g.2. Atomic frequency standards ...

3.B.1.a.2. Metal organic chemical vapour deposition reactors ...

3.D.1. "Software" specially designed for the "development" or "production" of equipment in **3.A.2.g. or 3.B. of this Annex**.

3.E.1. "Technology" according to the General Technology Note for the "development" or "production" of equipment in **3.A. or 3.B. of this Annex**.

Category 4

4.A.1.a.2. Electronic computers ... radiation hardened;

4.A.3.b. "Digital computers" having a "composite theoretical performance" ("CTP") exceeding **75,000 Mtops**.

4.A.3.c. "Electronic assemblies" specially designed or modified for enhancing performance by aggregation of "computing elements" ("CEs") so that the "CTP" of the aggregation exceeds the limit in 4.A.3.b. **in this Annex**.

Dual-Use List - ANNEX 1

Category 4 (contd.)

Note 1 ***4.A.3.c. applies only to "electronic assemblies" and programmable interconnections not exceeding the limit in 4.A.3.b. in this Annex when shipped as unintegrated "electronic assemblies".***

Note 2 *4.A.3.c. does not control "electronic assemblies" specially designed for a product or family of products whose maximum configuration does not exceed the limit of 4.A.3.b. in this Annex.*

4.D.1. **"Software" specially designed for the "development" or "production" of equipment or "software" in 4.A. or 4.D. of this Annex.**

4.E.1. **"Technology" according to the General Technology Note for the "development" or "production" of equipment or "software" in 4.A. or 4.D. of this Annex.**

Category 5 - Part 1

5.A.1.b.3. Being radio equipment ...

5.A.1.b.4. Being digitally controlled radio receivers ...

5.B.1.a. Equipment and specially designed components or accessories therefor, specially designed for the "development", "production" or "use" of equipment, functions or features in Category 5 - Part 1 of this Annex.

5.D.1.a. **"Software" specially designed for the "development" or "production" of equipment, functions or features in Category 5 - Part 1 of this Annex.**

5.D.1.b. "Software" specially designed or modified to support "technology" listed under 5.E.1. of this Annex.

5.E.1.a. **"Technology" according to the General Technology Note for the "development" or "production" of equipment, functions, features or "software" in Category 5 - Part 1 of this Annex.**

Category 5 - Part 2 - None

Dual-Use List - ANNEX 1

Category 6

6.A.1.a.1.b. Object detection or location systems having any of the following:
1. A transmitting frequency below **5 kHz**;
2. Sound pressure level exceeding 224 dB (reference 1 µPa at 1 m) for equipment with an operating frequency in the band from **5 kHz** to 24 kHz inclusive;
3. Sound pressure level ...;
4. Forming beams of ...;
5. Designed to operate ...;
6. Designed to withstand ...;

6.A.1.a.2.a.1. Hydrophones ... Incorporating ...

6.A.1.a.2.a.2. Hydrophones ... Having any ...

6.A.1.a.2.a.7. Hydrophones ... Designed for ...

6.A.1.a.2.b. Towed acoustic hydrophone arrays ...

6.A.1.a.2.c. Processing equipment, specially designed for **real time application with** towed acoustic hydrophone arrays, having "user accessible programmability" and time or frequency domain processing and correlation, including spectral analysis, digital filtering and beamforming using Fast Fourier or other transforms or processes;

6.A.1.a.2.d. Heading sensors ...

6.A.1.a.2.e. Bottom or bay cable systems having any of the following:
1. Incorporating hydrophones ... or
2. Incorporating multiplexed hydrophone group signal modules ...;

6.A.1.a.2.f. Processing equipment, specially designed for **real time application with** bottom or bay cable systems, having "user accessible programmability" and time or frequency domain processing and correlation, including spectral analysis, digital filtering and beamforming using Fast Fourier or other transforms or processes;

6.A.2.a.1.a. "Space-qualified" solid-state detectors ...

6.A.2.a.1.b. "Space-qualified" solid-state detectors ...

6.A.2.a.1.c. "Space-qualified" solid-state detectors ...

6.A.2.a.2.a. Image intensifier tubes ...
1. A peak response ...
2. A microchannel plate ...
3. Photocathodes, as follows:
   a. **S-20, S-25 or multialkali photocathodes with a luminous sensitivity exceeding 550 µA/lm;**
   b. GaAs or GaInAs photocathodes;
   c. Other III-V compound semiconductor photocathodes.

Dual-Use List - ANNEX 1

Category 6 (contd.)

6.A.2.a.3. Non-space qualified "focal plane arrays" ...;

Note 3

In 6.A.2.a.3. the following "focal plane arrays" are not included in this Annex:

a. Platinum Silicide (PtSi) "focal plane arrays" having less than 10,000 elements;

b. Iridium Silicide (IrSi) "focal plane arrays".

6.A.2.a.3. Note 4

In 6.A.2.a.3. the following "focal plane arrays" are not included in this Annex:

a. Indium Antimonide (InSb) or Lead Selenide (PbSe) "focal plane arrays" having less than 256 elements;

b. Indium Arsenide (InAs) "focal plane arrays";

c. Lead Sulphide (PbS) "focal plane arrays";

d. Indium Gallium Arsenide (InGaAs) "focal plane arrays".

Note 5

In 6.A.2.a.3. Mercury Cadmium Telluride (HgCdTe) "focal plane arrays" as follows are not included in this Annex:

1. Scanning Arrays having any of the following:

a. 30 elements or less; or

b. incorporating time delay-and-integration within the element and having 2 elements or less;

2. Staring Arrays having less than 256 elements.

6.A.2.a.3. *Technical Notes*

'Scanning Arrays' are defined as "focal plane arrays" designed for use with a scanning optical system that images a scene in a sequential manner to produce an image;

'Staring Arrays' are defined as "focal plane arrays" designed for use with a non-scanning optical system that images a scene.

Note 6

In 6.A.2.a.3. the following "focal plane arrays" are not included in this Annex:

a. Gallium Arsenide (GaAs) or Gallium Aluminum Arsenide (GaAlAs) quantum well "focal plane arrays" having less than 256 elements;

b. Pyroelectric or Ferroelectric (including barium-strontium titanate, lead zirconate titanate or lead scandium titanate) "focal plane arrays" having less than 8,000 elements;

c. Vanadium Oxide-Silicon nitride microbolometer "focal plane arrays" having less than 8,000 elements.

Dual-Use List - ANNEX I

Category 6 (contd.)

6.A.2.b.	"Monospectral imaging sensors" and "multispectral imaging sensors" ....
6.A.2.c.	Direct view imaging equipment operating in the visible or infrared spectrum, incorporating any of the following: 1. Image intensifier tubes having the characteristics listed in **6.A.2.a.2.a. of this Annex**; or 2. "Focal plane arrays" having the characteristics listed in **6.A.2.a.3. of this Annex**.
6.A.2.e.	"Space-qualified" "focal plane arrays" ...
6.A.3.b.3.	Imaging cameras incorporating image intensifier tubes having the characteristics listed in **6.A.2.a.2.a. of this Annex**.
6.A.3.b.4.	Imaging cameras incorporating "focal plane arrays" having the characteristics listed in **6.A.2.a.3. of this Annex**;
6.A.4.c.	"Space-qualified" components for optical systems ...
6.A.4.d.	Optical control equipment ...
6.A.6.g.	Magnetic compensation systems ... *Note* ***In 6.A.6.g. those compensators which provide only absolute values of the earth's magnetic field as output (i.e., the frequency bandwidth of the output extends from DC to at least 0.8 Hz) are not included in this Annex.***
6.A.6.h.	"Superconductive" electromagnetic sensors ...
6.A.8.d.	Radar systems ... Capable of ...
6.A.8.h.	Radar systems ... Employing processing ...
6.A.8.k.	Radar systems ... Having "signal processing" ...
6.A.8.1.3.	Radar systems ... Having data processing ... Processing for ...
6.B.8.	Pulse radar cross-section ...
6.D.1.	"Software" specially designed for the "development" or "production" of equipment in **6.A.4., 6.A.8. or 6.B.8. of this Annex**.
6.D.3.a.	"Software", as follows: ...
6.E.1.	"Technology" according to ...
6.E.2.	**"Technology" according to the General Technology Note for the "production" of equipment in 6.A. or 6.B. of this Annex.**

Category 7

7.D.2.	"Source code" for the "use" ...
7.D.3.a.	"Software" specially designed or modified to ...
7.D.3.b.	"Source code" for ...
7.D.3.c.	"Source code" for ...
7.D.3.d.1. to 4. & 7.	"Source code" for the "development" of ...
7.E.1. & 7.E.2.	"Technology" according to the General Technology Note ...

Dual-Use List - ANNEX 1

Category 8

8.A.1.b.	Manned, untethered submersible vehicles ...
8.A.1.c.	Unmanned, tethered submersible vehicles ...
8.A.1.d.	Unmanned, untethered submersible vehicles ...
8.A.2.b.	Systems specially designed or modified for the automated control of the motion of submersible vehicles **in 8.A.1. of this Annex** using navigation data and having closed loop servo-controls: 1. Enabling ...; 2. Maintaining ...; or 3. Maintaining ...;
8.A.2.h.	"Robots" specially designed for underwater use ...
8.A.2.j.	Air independent power systems ...
8.A.2.o.3.	Noise reduction systems for use on vessels ...
8.A.2.p.	Pumpjet propulsion systems ...
8.D.1.	**"Software" specially designed for the "development" or "production" of equipment in 8.A. of this Annex.**
8.D.2.	Specific "software" ...
8.E.1.	"Technology" according to the General Technology Note for the "development" or "production" of equipment in **8.A. of this Annex.**
8.E.2.a.	Other "technology" ...

Category 9

9.A.11.	Ramjet, scramjet or combined cycle engines ...
9.B.1.b.	Ceramic cores or shells
9.D.1.	**"Software" specially designed or modified for the "development" of equipment or "technology" in 9.A., 9.B. or 9.E.3. of this Annex.**
9.D.2.	**"Software" specially designed or modified for the "production" of equipment in 9.A. or 9.B. of this Annex.**
9.D.4.a.	Other "software" ... 2D or 3D ...
9.D.4.c.	Other "software" ... "Software" specially ...
9.E.1.	"Technology" according to the General Technology Note ...
9.E.2.	"Technology" according to the General Technology Note ...
9.E.3.a.1.	Other "technology" ... Gas turbine blades ...
9.E.3.a.2. to 5. & 9.E.3.a.8., 9.E.3.a.9.	Other "technology" ...

Dual-Use List - ANNEX 2

ANNEX 2 OF THE LIST OF DUAL-USE GOODS AND TECHNOLOGIES

Note *This Annex is a sub-set of the Items contained in Annex 1.*

N.B. *Where abbreviated entries are used, see List of Dual-Use Goods and Technologies for full details. Text that differs from that in the List of Dual-Use Goods and Technologies is* ***shaded****.*

Category 1

1.A.2.a.	**"Composite" structures or laminates having an organic "matrix" and made from materials listed under 1.C.10.c. or 1.C.10.d.**
1.C.1.	Materials specially designed for use as absorbers of electromagnetic waves ...
1.C.12.	Materials as follows ...
1.E.1.	"Technology" according to the General Technology Note for the "development" or "production" of equipment and materials in **1.A.2. or 1.C. of this Annex**.

Category 2 None

Category 3 None

Category 4

4.A.3.b.	"Digital computers" having a "composite theoretical performance" ("CTP") exceeding **150,000 Mtops**.
4.A.3.c.	"Electronic assemblies" specially designed or modified for enhancing performance by aggregation of "computing elements" ("CEs") so that the "CTP" of the aggregation exceeds the limit in 4.A.3.b. **in this Annex**.

Note 1 ***4.A.3.c. applies only to "electronic assemblies" and programmable interconnections not exceeding the limit in 4.A.3.b. in this Annex when shipped as unintegrated "electronic assemblies".***

Note 2 *4.A.3.c. does not control "electronic assemblies" specially designed for a product or family of products whose maximum configuration does not exceed the limit of 4.A.3.b.* ***in this Annex****.*

4.D.1.	**"Software" specially designed for the "development" or "production" of equipment in 4.A. of this Annex.**
4.E.1.	**"Technology" according to the General Technology Note for the "development" or "production" of equipment or "software" in 4.A. or 4.D. of this Annex.**

Dual-Use List - ANNEX 2

Category 5 - Part 1

5.A.1.b.4. Digitally controlled radio receivers ...

5.D.1.a. **"Software" specially designed for the "development" or "production" of equipment, functions or features in Category 5, Part 1 of this Annex.**

5.E.1.a. **"Technology" according to the General Technology Note for the "development" or "production" of equipment, functions, features or "software" in Category 5, Part 1 of this Annex.**

Category 5 - Part 2 None

Category 6

6.A.1.a.2.a.1., 2. & 7. Hydrophones ... Incorporating ...
6.A.1.a.2.b. Towed acoustic hydrophone arrays ...

6.A.1.a.2.c. Processing equipment, specially designed for **real time application with** towed acoustic hydrophone arrays, having "user accessible programmability" and time or frequency domain processing and correlation, including spectral analysis, digital filtering and beamforming using Fast Fourier or other transforms or processes;

6.A.1.a.2.e. Bottom or bay cable systems having any of the following:
1. Incorporating hydrophones ... or
2. Incorporating multiplexed hydrophone group signal modules ...;

6.A.1.a.2.f. Processing equipment, specially designed for **real time application with** bottom or bay cable systems, having "user accessible programmability" and time or frequency domain processing and correlation, including spectral analysis, digital filtering and beamforming using Fast Fourier or other transforms or processes;

6.A.2.a.1.c. "Space-qualified" solid-state detectors ...
6.A.8.1.3. Radar systems ... Having data processing ... Processing for ...
6.B.8. Pulse radar cross-section ...

6.D.1. "Software" specially designed for the "development" or "production" of equipment in **6.A.8., or 6.B.8. of this Annex**.
6.D.3.a. "Software", as follows: ...

6.E.1. "Technology" according to the General Technology Note for the "development" of **equipment or "software" in 6.A., 6.B., or 6.D. of this Annex.**

6.E.2. "Technology" according to the General Technology Note for the "production" of equipment in **6.A. or 6.B. of this Annex**.

Dual-Use List - ANNEX 2

Category 7

7.D.3.a.	"Software" specially designed or modified to ...
7.D.3.b.	"Source code" for ...

Category 8

8.A.1.b.	Manned, untethered submersible vehicles ...
8.A.1.d.	Unmanned, untethered submersible vehicles ...
8.A.2.o.3.b.	Active noise reduction or cancellation systems ...
8.D.1.	**"Software" specially designed for the "development" or "production" of equipment in 8.A. of this Annex.**
8.E.1.	"Technology" according to the General Technology Note for the "development" or "production" of equipment in **8.A. of this Annex.**

Category 9

9.A.11.	Ramjet, scramjet or combined cycle engines ...
9.D.1.	**"Software" specially designed or modified for the "development" of equipment or "technology" in 9.A. or 9.E.3. of this Annex.**
9.D.2.	**"Software" specially designed or modified for the "production" of equipment in 9.A. of this Annex.**
9.E.1.	"Technology" according to the General Technology Note for the "development" of equipment or "software" in **9.A.11. or 9.D. of this Annex.**
9.E.2.	"Technology" according to the General Technology Note for the "production" of equipment in **9.A.11. of this Annex.**
9.E.3.a.1.	Other "technology" ... Gas turbine blades ...
9.E.3.a.3.a.	"Technology" "required" for ... Components manufactured from ... Organic "composite" materials designed to operate above 588 K (315°C).

DEFINITIONS

DEFINITIONS OF TERMS USED IN THESE LISTS

This document contains the definitions of the terms used in these Lists, in alphabetical order.

Note 1 *Definitions apply throughout the Lists and their Annexes. The references are purely advisory and have no effect on the universal application of defined terms throughout these Lists and their Annexes.*

Note 2 *Words and terms contained in the List of Definitions only take the defined meaning where this is indicated by their being enclosed in quotation marks (" "). Elsewhere, words and terms take their commonly accepted (dictionary) meanings, unless a local definition for a particular control is given. (See also 'Statements of Understanding and Validity Notes – Definition of Terms used in these Lists').*

DEFINITIONS

Cat 2
Cat 6 "Accuracy"
(Usually measured in terms of inaccuracy) is the maximum deviation, positive or negative, of an indicated value from an accepted standard or true value.

Cat 7 "Active flight control systems"
Function to prevent undesirable "aircraft" and missile motions or structural loads by autonomously processing outputs from multiple sensors and then providing necessary preventive commands to effect automatic control.

Cat 6
Cat 8 "Active pixel"
A minimum (single) element of the solid state array which has a photoelectric transfer function when exposed to light (electromagnetic) radiation.

Cat 1 "Adapted for use in war"

Cat 2 "Adaptive control"
A control system that adjusts the response from conditions detected during the operation (Reference: ISO 2806-1980).

Cat 1
Cat 7 & 9 "Aircraft"
A fixed wing, swivel wing, rotary wing (helicopter), tilt rotor or tilt-

Cat 2 "All compensations available"
"All compensations available" means after all feasible measures available to the manufacturer to minimise all systematic positioning errors for the particular machine-tool model are considered.

Cat 3
Cat 5 P1 "Allocated by the ITU"
The allocation of frequency bands according to the ITU Radio Regulations (Edition 1998) for primary, permitted and secondary services.
N.B. Additional and alternative allocations are not included.

Cat 2 "Angular position deviation"
The maximum difference between angular position and the actual, very accurately measured angular position after the workpiece mount of the table has been turned out of its initial position. (Reference: VDI/VDE 2617, Draft: 'Rotary tables on coordinate measuring machines').

Cat 5 "Asymmetric algorithm"
A cryptographic algorithm using different, mathematically related keys for encryption and decryption.
Technical Note
A common use of "asymmetric algorithms" is key management.

Cat 5 "Asynchronous transfer mode" ("ATM")
A transfer mode in which the information is organised into cells; it is asynchronous in the sense that the recurrence of cells depends on the required or instantaneous bit rate.

DEFINITIONS

Cat 5 "ATM"

"ATM" is equivalent to "Asynchronous transfer mode".

Cat 6 "Automatic target tracking"

A processing technique that automatically determines and provides as output an extrapolated value of the most probable position of the target in real time.

Cat 3 "Basic gate propagation delay time"

The propagation delay time value corresponding to the basic gate used in a "monolithic integrated circuit". For a 'family' of "monolithic integrated circuits", this may be specified either as the propagation delay time per typical gate within the given 'family' or as the typical propagation delay time per gate within the given 'family'.

Technical Notes

1. *"Basic gate propagation delay time" is not to be confused with the input/output delay time of a complex "monolithic integrated circuit".*
2. *'Family' consists of all integrated circuits to which all of the following are applied as their manufacturing methodology and specifications except their respective functions:*
   a. The common hardware and software architecture;
   b. The common design and process technology; and
   c. The common basic characteristics.

GTN "Basic scientific research"

Experimental or theoretical work undertaken principally to acquire new knowledge of the fundamental principles of phenomena or observable facts, not primarily directed towards a specific practical aim or objective.

Cat 7 "Bias" (accelerometer)

An accelerometer output when no acceleration is applied.

Cat 2 "Camming" (axial displacement)

Axial displacement in one revolution of the main spindle measured in a plane perpendicular to the spindle faceplate, at a point next to the circumference of the spindle faceplate (Reference: ISO 230/1 1986, paragraph 5.63).

Cat 1 "Carbon fibre preforms"

An ordered arrangement of uncoated or coated fibres intended to constitute a framework of a part before the "matrix" is introduced to form a "composite".

Cat 4 "CE"

"CE" is equivalent to "computing element".

Cat 6 "Chemical Laser"

A "laser" in which the excited species is produced by the output energy from a chemical reaction.

"Circuit element"

A single active or passive functional part of an electronic circuit, such as one diode, one transistor, one resistor, one capacitor, etc.

DEFINITIONS

Cat 7 "Circulation-controlled anti-torque or circulation-controlled direction control systems"
Control systems using air blown over aerodynamic surfaces to increase or control the forces generated by the surfaces.

Cat 1 "Civil aircraft"
Cat 7 Those "aircraft" listed by designation in published airworthiness certification lists by the
Cat 9 civil aviation authorities to fly commercial civil

Cat 1 "Commingled"
Filament to filament blending of thermoplastic fibres and reinforcement fibres in order to produce a fibre reinforcement "matrix" mix in total fibre form.

Cat 1 "Comminution"
A process to reduce a material to particles by crushing or grinding.

Cat 5 "Common channel signalling"
A signalling method in which a single channel between exchanges conveys, by means of labelled messages, signalling information relating to a multiplicity of circuits or calls and other information such as that used for network management.

Cat 4 "Communications channel controller"
The physical interface which controls the flow of synchronous or asynchronous digital information. It is an assembly that can be integrated into computer or telecommunications equipment to provide communications access.

Cat 1 "Composite"
Cat 2 A "matrix" and an additional phase or additional phases consisting of particles, whiskers,
Cat 6 fibres or any combination thereof, present for a specific purpose or purposes.
Cat 8 & 9

Cat 3 "Composite theoretical performance" ("CTP")
Cat 4 A measure of computational performance given in millions of theoretical operations per second (Mtops), calculated using the aggregation of "computing elements"
N. B. See Category 4, Technical Note.

Cat 2 "Compound rotary table"
A table allowing the workpiece to rotate and tilt about two non-parallel axes, which can be coordinated simultaneously for "contouring control".

Cat 4 "Computing element" ("CE")
The smallest computational unit that produces an arithmetic or logic result.

Cat 2 "Contouring control"
Two or more "numerically controlled" motions operating in accordance with instructions that specify the next required position and the required feed rates to that position. These feed rates are varied in relation to each other so that a desired contour is generated (Ref. ISO/DIS 2806 - 1980).

DEFINITIONS

Cat 1
Cat 3
Cat 6

"Critical temperature"

(sometimes referred to as the transition temperature) of a specific "superconductive" material is the temperature at which the material loses all resistance to the flow of direct electrical current.

Cat 5

"Cryptography"

The discipline which embodies principles, means and methods for the transformation of data in order to hide its information content, prevent its undetected modification or prevent its unauthorized use. "Cryptography" is limited to the transformation of information using one or more secret parameters (e.g., crypto variables) or associated key management.

Technical Note

'Secret parameter': a constant or key kept from the knowledge of others or shared only within a group.

Cat 3
Cat 4

"CTP"

"CTP" is equivalent to "Composite theoretical performance".

Cat 5

"Data signalling rate"

The rate, as defined in ITU Recommendation 53-36, taking into account that, for non-binary modulation, baud and bit per second are not equal. Bits for coding, checking and synchronisation functions are to be included.

Note *When determining the "data signalling rate", servicing and administrative channels shall be excluded.*

Technical Note

It is the maximum one-way rate, i.e., the maximum rate in either transmission or reception.

Cat 6

"Deformable Mirrors"

Mirrors:

a. Having a single continuous optical reflecting surface which is dynamically deformed by the application of individual torques or forces to compensate for distortions in the optical waveform incident upon the mirror; or

b. Having multiple optical reflecting elements that can be individually and dynamically repositioned by the application of torques or forces to compensate for distortions in the optical waveform incident upon the mirror.

"Deformable mirrors" are also known as adaptive optic mirrors.

GTN
Both Lists

"Development"

Is related to all stages prior to serial production, such as: design, design research, design analyses, design concepts, assembly and testing of prototypes, pilot production schemes, design data, process of transforming design data into a product, configuration design, integration design, layouts.

Cat 1
Cat 2
Cat 9

"Diffusion bonding"

A solid state molecular joining of at least two separate metals into a single piece with a joint strength equivalent to that of the weakest material.

DEFINITIONS

Cat 4 "Digital computer"

Cat 5 Equipment which can, in the form of one or more discrete variables, perform all of the following:

a. Accept data;
b. Store data or instructions in fixed or alterable (writable) storage devices;
c. Process data by means of a stored sequence of instructions which is modifiable; and
d. Provide output of data.

Technical Note

Modifications of a stored sequence of instructions include replacement of fixed storage devices, but not a physical change in wiring or interconnections.

Cat 5 "Digital transfer rate"

The total bit rate of the information that is directly transferred on any type of medium. (See also "total digital transfer rate").

Cat 2 "Direct-acting hydraulic pressing"

A deformation process which uses a fluid-filled flexible bladder in direct contact with the workpiece.

"Discrete component"

A separately packaged "circuit element" with its own external connections.

Cat 7 "Drift rate" (gyro)

The time rate of output deviation from the desired output. It consists of random and systematic components and is expressed as an equivalent input angular displacement per unit time with respect to inertial space.

Cat 5 "Dynamic adaptive routing"

Automatic rerouting of traffic based on sensing and analysis of current actual network conditions.

Note *This does not include cases of routing decisions taken on predefined information.*

Cat 3 "Dynamic signal analysers"

"Signal analysers" which use digital sampling and transformation techniques to form a Fourier spectrum display of the given waveform including amplitude and phase information.

Cat 1 "Effective gram"

"Effective gram" for plutonium isotope is defined as the isotope weight in grams.

Cat 5 "Electronically steerable phased array antenna"

Cat 6 An antenna which forms a beam by means of phase coupling, (i.e., the beam direction is controlled by the complex excitation coefficients of the radiating elements) and the direction of that beam can be varied (both in transmission and reception) in azimuth or in elevation, or both, by application of an electrical signal.

DEFINITIONS

Cat 3 "Electronic assembly"
Cat 4
Cat 5 A number of electronic components (i.e., "circuit elements", "discrete components", integrated circuits, etc.) connected together to perform (a) specific function(s), replaceable as an entity and normally capable of being disassembled.

Cat 2 "End-effectors"

Cat 6 "Equivalent Density"
The mass of an optic per unit optical area projected onto the optical surface.

Cat 4 "Expert systems"
Cat 7 Systems providing results by application of rules to data which are stored independently of the "programme" and capable of any of the following:
a. Modifying automatically the "source code" introduced by the user;
b. Providing knowledge linked to a class of problems in quasi-natural language;
or
c. Acquiring the knowledge required for their development (symbolic training).

Cat 7 "FADEC"
Cat 9 Full Authority Digital Engine Control (FADEC) - an electronic control system for gas turbine or combined cycle engines utilising a digital computer to control the variables required to regulate engine thrust or shaft power output throughout the engine operating range from the beginning of fuel metering to fuel shutoff.

Cat 4 "Fault tolerance"
The capability of a computer system, after any malfunction of any of its hardware or "software" components, to continue to operate without human intervention, at a given level of service that provides continuity of operation, data integrity and recovery of service within a given time.

Cat 1 "Fibrous or filamentary materials"
Cat 8 Include:
a. Continuous monofilaments;
b. Continuous yarns and rovings;
c. Tapes, fabrics, random mats and braids;
d. Chopped fibres, staple fibres and coherent fibre blankets;
e. Whiskers, either monocrystalline or polycrystalline, of any length;
f. Aromatic polyamide pulp.

Cat 3 "Film type integrated circuit"
An array of "circuit elements" and metallic interconnections formed by deposition of a thick or thin film on an insulating "substrate".
Cat 5 "Fixed"
The coding or compression algorithm cannot accept externally supplied parameters (e.g., cryptographic or key variables) and cannot be modified by the user.

DEFINITIONS

Cat 7 "Flight control optical sensor array"

A network of distributed optical sensors, using "laser" beams, to provide real-time flight control data for on-board processing.

Cat 7 "Flight path optimization"

A procedure that minimizes deviations from a four-dimensional (space and time) desired trajectory based on maximizing performance or effectiveness for mission tasks.

Cat 6 "Focal plane array"

A linear or two-dimensional planar layer, or combination of planar layers, of individual detector elements, with or without readout electronics, which work in the focal plane.

Note *This definition does not include a stack of single detector elements or any two, three or four element detectors provided time delay and integration is not performed within the element.*

Cat 3 "Fractional bandwidth"

The "instantaneous bandwidth" divided by the centre frequency, expressed as a percentage.

Cat 5 "Frequency hopping"

A form of "spread spectrum" in which the transmission frequency of a single communication channel is made to change by a random or pseudo-random sequence of discrete steps.

Cat 3 "Frequency switching time"

Cat 5

The maximum time (i.e., delay) taken by a signal, when switched from one selected output frequency to another selected output frequency, to reach any of the following:

a. A frequency within 100 Hz of the final frequency; or

b. An output level within 1 dB of the final output level.

Cat 3 "Frequency synthesiser"

Any kind of frequency source or signal generator, regardless of the actual technique used, providing a multiplicity of simultaneous or alternative output frequencies, from one or more outputs, controlled by, derived from or disciplined by a lesser number of standard (or master) frequencies.

Cat 1 "Gas atomisation"

A process to reduce a molten stream of metal alloy to droplets of 500 µm diameter or less by a high pressure gas stream.

Cat 6 "Geographically dispersed"

Sensors are considered "geographically dispersed" when each location is distant from any other more than 1,500 m in any direction. Mobile sensors are always considered "geographically dispersed".

Cat 4 "Global interrupt latency time"

The time taken by the computer system to recognize an interrupt due to the event, service the interrupt and perform a context switch to an alternate memory-resident task waiting on the interrupt.

DEFINITIONS

Cat 2 "Hot isoetatic densification"

A process of pressurising a casting at temperatures exceeding 375 K (102°C) in a closed cavity through various media (gas, liquid, solid particles, etc.) to create equal force in all directions to reduce or eliminate internal voids in the casting.

Cat 4 "Hybrid computer"

Equipment which can perform all of the following:

a. Accept data;
b. Process data, in both analogue and digital representations; and
c. Provide output of data.

Cat 3 "Hybrid integrated circuit"

Any combination of integrated circuit(s), or integrated circuit with "circuit elements" or "discrete components" connected together to perform (a) specific function(s), and having all of the following characteristics:

a. Containing at least one unencapsulated device;
b. Connected together using typical IC production methods;
c. Replaceable as an entity; and
d. Not normally capable of being disassembled.

Cat 4 "Image enhancement"

The processing of externally derived information-bearing images by algorithms such as time compression, filtering, extraction, selection, correlation, convolution or transformations between domains (e.g., fast Fourier transform or Walsh transform). This does not include algorithms using only linear or rotational transformation of a single image, such as translation, feature extraction, registration or false coloration.

Cat 5 "Information security"

All the means and functions ensuring the accessibility, confidentiality or integrity of information or communications, excluding the means and functions intended to safeguard against malfunctions. This includes "cryptography", cryptanalysis, protection against compromising emanations and computer security.

Technical Note

'Cryptanalysis': the analysis of a cryptographic system or its inputs and outputs to derive confidential variables or sensitive data, including clear text. (ISO 7498-2-1988 (E), paragraph 3.3.18).

Cat 3 "Instantaneous bandwidth"
Cat 5P1

The bandwidth over which output power remains constant within 3 dB without adjustment of other operating parameters.

Cat 6 "Instrumented range"

The specified unambiguous display range of a radar.

Cat 6 "Interconnected radar sensors"

Two or more radar sensors are interconnected when they mutually exchange data in real time.

GTN "In the public domain"

DEFINITIONS

GSN — This means "technology" or "software" which has been made available without restrictions upon its further dissemination.

Note *Copyright restrictions do not remove "technology" or "software" from being "in the public domain".*

Cat 6 — "Intrinsic magnetic gradiometer"

A single magnetic field gradient sensing element and associated electronics the output of which is a measure of magnetic field gradient.

Cat 2 — "Isostatic presses"

Equipment capable of pressurising a closed cavity through various media (gas, liquid, solid particles, etc.) to create equal pressure in all directions within the cavity upon a workpiece or material.

Cat 2, 3, 5 6 & 9 — "Laser"

An assembly of components which produce both spatially and

Cat 2 — "Linearity"

(Usually measured in terms of non-linearity) is the maximum deviation of the actual characteristic (average of upscale and downscale readings), positive or negative, from a straight line so positioned as to equalise and minimise the maximum deviations.

Cat 4 — "Local area network"

A data communication system having all of the following characteristics:

a. Allows an arbitrary number of independent data devices to communicate directly with each other; and

b. Is confined to a geographical area of moderate size (e.g., office building, plant, campus, warehouse).

Technical Note

'Data device' means equipment capable of transmitting or receiving sequences of digital information.

Cat 6 — "Magnetic gradiometers"

Are designed to detect the spatial variation of magnetic fields from sources external to the instrument. They consist of multiple "magnetometers" and associated electronics the output of which is a measure of magnetic field gradient. (See also "Intrinsic Magnetic Gradiometer")

Cat 6 — "Magnetometers"

Are designed to detect magnetic fields from sources external to the instrument. They consist of a single magnetic field sensing element and associated electronics the output of which is a measure of the magnetic field.

Cat 4 — "Main storage"

The primary storage for data or instructions for rapid access by a central processing unit. It consists of the internal storage of a "digital computer" and any hierarchical extension thereto, such as cache storage or non-sequentially accessed extended storage.

DEFINITIONS

Cat 1
Cat 2
Cat 8 & 9

"Matrix"

A substantially continuous phase that fills the space between particles, whiskers or fibres.

Cat 2

"Measurement uncertainty"

The characteristic parameter which specifies in what range around the output value the correct value of the measurable variable lies with a confidence level of 95% It includes the uncorrected systematic deviations, the uncorrected backlash and the random deviations (Reference: ISO 10360-2, or VDI/VDE 2617).

Cat 1

"Mechanical alloying"

An alloying process resulting from the bonding, fracturing and rebonding of elemental and master alloy powders by mechanical impact. Non-metallic particles may be incorporated in the alloy by addition of the appropriate powders.

Cat 1

"Melt extraction"

A process to "solidify rapidly" and extract a ribbon-like alloy product by the insertion of a short segment of a rotating chilled block into a bath of a molten metal alloy.

Cat 1

"Melt spinning"

A process to "solidify rapidly" a molten metal stream impinging upon a rotating chilled block, forming a flake, ribbon or rod-like product.

Cat 3

"Microcomputer microcircuit"

A "monolithic integrated circuit" or "multichip integrated circuit" containing an arithmetic logic unit (ALU) capable of executing general purpose instructions from an internal storage, on data contained in the internal storage.

Technical Note

The internal storage may be augmented by an external storage.

Cat 3

"Microprocessor microcircuit"

A "monolithic integrated circuit" or "multichip integrated circuit" containing an arithmetic logic unit (ALU) capable of executing a series of general purpose instructions from an external storage.

Technical Note

The "microprocessor microcircuit" normally does not contain integral user-accessible storage, although storage present on-the-chip may be used in performing its logic function.

Note *This definition includes chip sets which are designed to operate together to provide the function of a "microprocessor microcircuit".*

"Microprogramme"

A sequence of elementary instructions maintained in a special storage, the execution of which is initiated by the introduction of its reference instruction register.

Cat 3

"Monolithic integrated circuit"

A combination of passive or active "circuit elements" or both which:

a. Are formed by means of diffusion processes, implantation processes or deposition processes in or on a single semiconducting piece of material, a so-called 'chip';

DEFINITIONS

b. Can be considered as indivisibly associated; and
c. Perform the function(s) of a circuit.

Cat 6 "Monospectral imaging sensors"
Are capable of acquisition of imaging data from one discrete spectral band.

Cat 3 "Multichip integrated circuit"
Two or more "monolithic integrated circuits" bonded to a common "substrate".

Cat 4 "Multi-data-stream processing"
The "microprogramme" or equipment architecture technique which permits simultaneous processing of two or more data sequences under the control of one or more instruction sequences by means such as:
a. Single Instruction Multiple Data (SIMD) architectures such as vector or array processors;
b. Multiple Single Instruction Multiple Data (MSIMD) architectures;
c. Multiple Instruction Multiple Data (MIMD) architectures, including those which are tightly coupled, closely coupled or loosely coupled; or
d. Structured arrays of processing elements, including systolic arrays.

Cat 5 "Multilevel security"
A class of system containing information with different sensitivities that simultaneously permits access by users with different security clearances and needs-to-know, but prevents users from obtaining access to information for which they lack authorization.
Technical Note
"Multilevel security" is computer security and not computer reliability which deals with equipment fault prevention or human error prevention in general.

Cat 6 "Multispectral imaging sensors"
Are capable of simultaneous or serial acquisition of imaging data from two or more discrete spectral bands. Sensors having more than twenty discrete spectral bands are sometimes referred to as hyperspectral imaging sensors.

Cat 4 "Network access controller"
A physical interface to a distributed switching network. It uses a common medium which operates throughout at the same "digital transfer rate" using arbitration (e.g., token or carrier sense) for transmission. Independently from any other, it selects data packets or data groups (e.g., IEEE 802) addressed to it. It is an assembly that can be integrated into computer or telecommunications equipment to provide communications access.

Cat 4 "Neural computer"
A computational device designed or modified to mimic the behaviour of a neuron or a collection of neurons, i.e., a computational device which is distinguished by its hardware capability to modulate the weights and numbers of the interconnections of a multiplicity of computational components based on previous data.

DEFINITIONS

Cat 6 "Noise level"

An electrical signal given in terms of power spectral density. The relation between "noise level" expressed in peak-to-peak is given by S^2 pp = $8N_o(f_2-f_1)$, where Spp is the peak-to-peak value of the signal (e.g., nanoteslas), N_o is the power spectral density (e.g., (nanotesla)^2/Hz) and (f_2-f_1) defines the bandwidth of interest.

Cat 2 "Numerical control"

The automatic control of a process performed by a device that makes use of numeric data usually introduced as the operation is in progress (Ref. ISO 2382).

Cat 4
Cat 9 "Object code"

"Object code": An equipment executable form of a convenient expression of one or more processes ("source code" (or source language)) which has been converted by a programming system.

Cat 5 "Optical amplification"

In optical communications, an amplification technique that introduces a gain of optical signals that have been generated by a separate optical source, without conversion to electrical signals, i.e., using semiconductor optical amplifiers, optical fibre luminescent amplifiers.

Cat 4 "Optical computer"

A computer designed or modified to use light to represent data and whose computational logic elements are based on directly coupled optical devices.

Cat 3 "Optical integrated circuit"

A "monolithic integrated circuit" or a "hybrid integrated circuit", containing one or more parts designed to function as a photosensor or photoemitter or to perform (an) optical or (an) electro-optical function(s).

Cat 5 "Optical switching"

The routing of or switching of signals in optical form without conversion to electrical signals.

Cat 3 "Overall current density"

The total number of ampere-turns in the coil (i.e., the sum of the number of turns multiplied by the maximum current carried by each turn) divided by the total cross-section of the coil (comprising the superconducting filaments, the metallic matrix in which the superconducting filaments are embedded, the encapsulating material, any cooling channels, etc.).

Cat 6 "Peak power"

Energy per pulse in joules divided by the pulse duration in seconds.

Cat 5 "Personalised smart card"

A smart card containing a microcircuit which has been programmed for a specific application and cannot be reprogrammed for any other application by the user.

DEFINITIONS

Cat 7 "Power management"
Changing the transmitted power of the altimeter signal so that received power at the "aircraft" altitude is always at the minimum necessary to determine the altitude.

Cat 1 "Previously separated"
The application of any process intended to increase the concentration of the controlled isotope.

Cat 7 "Primary flight control"
"Aircraft" stability or manoeuvring control using force/moment generators, i.e. aerodynamic control surfaces or propulsive thrust vectoring.

Cat 4 "Principal element"
An element is a "principal element" when its replacement value is more than 35% of the total value of the system of which it is an element. Element value is the price paid for the element by the manufacturer of the system, or by the system integrator. Total value is the normal international selling price to unrelated parties at the point of manufacture or consolidation of shipment.

GTN "Production"
Means all production stages, such as: product engineering, manufacture, integration, assembly (mounting), inspection, testing, quality assurance.

Cat 2
Cat 4
Cat 5 & 6 "Programme"
A sequence of instructions to carry out a process in, or convertible into, a form executable by an electronic computer.

Cat 6 "Pulse compression"
The coding and processing of a radar signal pulse of long time duration to one of short time duration, while maintaining the benefits of high pulse energy.

Cat 6 "Pulse duration"
Duration of a "laser" pulse measured at Full Width Half Intensity (FWHI) levels.

Cat 6 "Q-switched laser"
A "laser" in which the energy is stored in the population inversion or in the optical resonator and subsequently emitted in a pulse.

Cat 6 "Radar frequency agility"
Any technique which changes, in a pseudo-random sequence, the carrier frequency of a pulsed radar transmitter between pulses or between groups of pulses by an amount equal to or larger than the pulse bandwidth.

Cat 6 "Radar spread spectrum"
Any modulation technique for spreading energy originating from a signal with a relatively narrow frequency band, over a much wider band of frequencies, by using random or pseudo-random coding.

DEFINITIONS

Cat 3 "Real-time bandwidth"

For "dynamic signal analysers", the widest frequency range which the analyser can output to display or mass storage without causing any discontinuity in the analysis of the input data. For analysers with more than one channel, the channel configuration yielding the widest "real-time bandwidth" shall be used to make the calculation.

Cat 2, 4
Cat 6 & 7 "Real time processing"

The processing of data by a computer system providing a required level of service, as a function of available resources, within a guaranteed response time, regardless of the load of the system, when stimulated by an external event.

Cat 5
Cat 6
Cat 9
GTN "Required"

As applied to "technology", refers to only that portion of "technology" which is peculiarly responsible for achieving or exceeding the controlled performance levels, characteristics or functions. Such "required" "technology" may be shared by different products.

Cat 2 "Resolution"

The least increment of a measuring device; on digital instruments, the least significant bit. (Reference: ANSI B-89.1.12)

Cat 2
Cat 8 "Robot"

A manipulation mechanism, which may be of the continuous path or of

Cat 1 "Rotary atomisation"

A process to reduce a stream or pool of molten metal to droplets to a diameter of 500 μm or less by centrifugal force.

Cat 2 "Run out" (out-of-true running)

Radial displacement in one revolution of the main spindle measured in a plane perpendicular to the spindle axis at a point on the external or internal revolving surface to be tested (Reference: ISO 230/1-1986, paragraph 5.61).

Cat 7 "Scale factor" (gyro or accelerometer)

The ratio of change in output to a change in the input intended to be measured. Scale factor is generally evaluated as the slope of the straight line that can be fitted by the method of least squares to input-output data obtained by varying the input cyclically over the input range.

Cat 3 "Settling time"

The time required for the output to come within one-half bit of the final value when switching between any two levels of the converter.

Cat 6 "SHPL"

"SHPL" is equivalent to "Super High Power Laser".

Cat 3 "Signal analysers"

Apparatus capable of measuring and displaying basic properties of the single-frequency components of multi-frequency signals.

DEFINITIONS

Cat 3
Cat 4
Cat 5
Cat 6

"Signal processing"

The processing of externally derived information-bearing signals by algorithms such as time compression, filtering, extraction, selection, correlation, convolution or transformations between domains (e.g., fast Fourier transform or Walsh transform).

Both Lists

"Software"

A collection of one or more "programmes" or "microprogrammes" fixed in any tangible medium of expression.

"Solidify rapidly"

A process involving the solidification of molten material at cooling rates exceeding 1,000 K/sec.

Cat 4
Cat 5
Cat 6
Cat 7
Cat 9

"Source code"

A convenient expression of one or more processes which may be turned by a programming system into equipment executable form ("object code" (or object language)).

Cat 7
Cat 9

"Spacecraft"

Active and passive satellites and space probes.

Cat 3
Cat 6

"Space qualified"

Products designed, manufactured and tested to meet the special electrical,

Cat 1

"Splat quenching"

A process to "solidify rapidly" a molten metal stream impinging upon a chilled block, forming a flake-like product.

Cat 5

"Spread spectrum"

The technique whereby energy in a relatively narrow-band communication channel is spread over a much wider energy spectrum.

Cat 6

"Spread spectrum" radar - see "Radar spread spectrum"

Cat 7

"Stability"

Standard deviation (1 sigma) of the variation of a particular parameter from its calibrated value measured under stable temperature conditions. This can be expressed as a function of time.

Cat 2
Cat 3
Cat 5

"Stored programme controlled"

A control using instructions stored in an electronic storage which a processor can execute in order to direct the performance of predetermined functions.

Technical Note

Equipment may be "stored programme controlled" whether the electronic storage is internal or external to the equipment.

Cat 3

"Substrate"

A sheet of base material with or without an interconnection pattern and on which or within which "discrete components" or integrated circuits or both can be located.

Cat 6

"Substrate blanks"

Monolithic compounds with dimensions suitable for the production of optical elements such as mirrors or optical windows.

DEFINITIONS

Cat 2
Cat 9 "Superalloy"
Nickel-, cobalt- or iron-base alloys having strengths superior to any alloys in the AISI 300 series at temperatures over 922 K (649°C) under severe environmental and operating conditions.

Cat 1
Cat 3
Cat 6
Cat 8 "Superconductive"
Refers to materials, (i.e., metals, alloys or compounds) which can lose all electrical resistance (i.e., which can attain infinite electrical conductivity and carry very large electrical currents without Joule heating).

Cat 6 "Super High Power Laser" ("SHPL")
A "laser" capable of delivering (the total or any portion of) the output energy exceeding 1 kJ within 50 ms or having an average or CW power exceeding 20 kW.

Cat 1
Cat 2 "Superplastic forming"
A deformation process using heat for metals that are normally characterised by low values of elongation (less than 20%) at the breaking point as determined at room temperature by conventional tensile strength testing, in order to achieve elongations during processing which are at least 2 times those values.

Cat 5 "Symmetric algorithm"
A cryptographic algorithm using an identical key for both encryption and decryption.
Technical Note
A common use of "symmetric algorithms" is confidentiality of data.

Cat 6 "System tracks"
Processed, correlated (fusion of radar target data to flight plan position) and updated aircraft flight position report available to the Air Traffic Control centre controllers.

Cat 4 "Systolic array computer"
A computer where the flow and modification of the data is dynamically controllable at the logic gate level by the user.

GTN & "Technology"

Cat 4 "Terminal interface equipment"
Equipment at which information enters or leaves the telecommunication system, e.g., telephone, data device, computer, facsimile device.

Cat 4 "Three dimensional Vector Rate"
The number of vectors generated per second which have 10 pixel poly line vectors, clip tested, randomly oriented, with either integer or floating point X-Y-Z coordinate values (whichever produces the maximum rate).

Cat 2 "Tilting spindle"
A tool-holding spindle which alters, during the machining process, the angular position of its centre line with respect to any other axis.

DEFINITIONS

Cat 6 "Time constant"

The time taken from the application of a light stimulus for the current increment to reach a value of 1-1/e times the final value (i.e., 63% of the final value).

Cat 7 "Total control of flight"

Automated control of "aircraft" state variables and flight path to meet mission objectives responding to real time changes in data regarding objectives, hazards or other "aircraft".

Cat 5 "Total digital transfer rate"

The number of bits, including line coding, overhead and so forth per unit time passing between corresponding equipment in a digital transmission system. (See also "digital transfer rate")

Cat 6 "Transfer laser"

A "laser" in which the lasing species is excited through the transfer of energy by collision of a non-lasing atom or molecule with a lasing atom or molecule species.

Cat 6 "Tunable"

The ability of a "laser" to produce a continuous output at all wavelengths over a range of several "laser" transitions. A line selectable "laser" produces discrete wavelengths within one "laser" transition and is not considered "tunable"

GTN
Cat 1, 2, 4
Cat 5, 6, 7
Cat 8 & 9 "Use"

Operation, installation (including on-site installation), maintenance (checking), repair, overhaul and refurbishing.

Cat 4
Cat 5
Cat 6 "User-accessible programmability"

The facility allowing a user to insert, modify or replace "programmes" by means other than:

a. A physical change in wiring or interconnections; or

b. The setting of function controls including entry of parameters.

Cat 1 "Vacuum atomisation"

A process to reduce a molten stream of metal to droplets of a diameter of 500 μm or less by the rapid evolution of a dissolved gas upon exposure to a vacuum.

Cat 7 "Variable geometry airfoils"

Use trailing edge flaps or tabs, or leading edge slats or pivoted nose droop, the position of which can be controlled in flight.

ACRONYMS AND ABBREVIATIONS

An acronym or abbreviation, when used as a defined term, will be found in "Definitions of Terms used in these Lists".

ACRONYM OR ABBREVIATION	MEANING
ABEC	Annular Bearing Engineers Committee
AGMA	American Gear Manufacturers' Association
AHRS	attitude and heading reference systems
ALU	arithmetic logic unit
ATC	air traffic control
C^3I	command, communications, control & intelligence
CAD	computer-aided-design
CAS	Chemical Abstracts Service
CDU	control and display unit
CEP	circular error probable
CNTD	controlled nucleation thermal deposition
CVD	chemical vapour deposition
CW	chemical warfare
CW (for lasers)	continuous wave
DEW	directed energy weapon systems
DME	distance measuring equipment
DS	directionally solidified
EB-PVD	electron beam physical vapour deposition
EBU	European Broadcasting Union
ECM	electro-chemical machining
ECR	electron cyclotron resonance
EDM	electrical discharge machines
EEPROMS	electrically erasable programmable read only memory
EIA	Electronic Industries Association
EMC	electromagnetic compatibility
EMCDB	elastomer modified cast double based propellants
FFT	Fast Fourier Transform
GLONASS	global navigation satellite system
GPS	global positioning system
HBT	hetero-bipolar transistors
HDDR	high density digital recording
HEMT	high electron mobility transistors
ICAO	International Civil Aviation Organisation
IEC	International Electro-technical Commission
IEEE	Institute of Electrical and Electronic Engineers
IFOV	instantaneous-field-of-view
ILS	instrument landing system
IRIG	inter-range instrumentation group
ISAR	inverse synthetic aperture radar
ISO	International Organization for Standardization
ITU	International Telecommunication Union
JIS	Japanese Industrial Standard

ACRONYM OR ABBREVIATION	MEANING
JT	Joule-Thomson
LIDAR	light detection and ranging
LRU	line replaceable unit
MAC	message authentication code
Mach	ratio of speed of an object to speed of sound (after Ernst Mach)
MLS	microwave landing systems
MOCVD	metal organic chemical vapour deposition
MRI	magnetic resonance imaging
MTBF	mean-time-between-failures
Mtops	million theoretical operations per second
MTTF	mean-time-to-failure
NBC	Nuclear, Biological and Chemical
NDT	non-destructive test
PAR	precision approach radar
PIN	personal identification number
ppm	parts per million
PSD	power spectral density
QAM	quadrature-amplitude-modulation
RF	radio frequency
RPV	remotely piloted air vehicles
SACMA	Suppliers of Advanced Composite Materials Association
SAR	synthetic aperture radar
SC	single crystal
SLAR	sidelooking airborne radar
SMPTE	Society of Motion Picture and Television Engineers
SRA	shop replaceable assembly
SRAM	static random access memory
SRM	SACMA Recommended Methods
SSB	single sideband
SSR	secondary surveillance radar
TCSEC	trusted computer system evaluation criteria
TIR	total indicated reading
UTS	ultimate tensile strength
VOR	very high frequency omni-directional range
YAG	yttrium/aluminum garnet

STATEMENTS OF UNDERSTANDING AND VALIDITY NOTES

Intangible Transfers of Software and Technology

Participating States recognize that it is important to have comprehensive controls on listed "software" and "technology", including controls on intangible transfers. Participating States also recognize that it is important to continue deepening understanding of how and how much to control those transfers. Those countries currently not having legislation to permit control should consider whatever action is necessary to address this issue.

DUAL-USE LIST OF GOODS AND TECHNOLOGIES

General Technology Note (NF (95) CA WP 1)

Governments agree that the transfer of "technology" according to the General Technology Note, for "production" or "development" of items on this list shall be treated with vigilance in accordance with national policies and the aims of this regime.

General Technology Note (WG2 GTN TWG/WP1 Revised 2)

It is understood that Member Governments are expected to exercise controls on intangible "technology" as far as the scope of their legislation will allow.

General Software Note (NF (95) CA WP 1)

Governments agree that the transfer of "software", for "production" or "development" of items on this list shall be treated with vigilance in accordance with national policies and the aims of this regime.

Statement of Understanding - medical equipment (NF (96) DG PL/WP1)

Participating countries agree that equipment specially designed for medical end-use that incorporates an item controlled in the Dual-Use List is not controlled.

STATEMENTS OF UNDERSTANDING AND VALIDITY NOTES

Category 2

2.B.1.

Validity Note 2.B.1. is valid until 5 December 2001 and renewal of the agreed parameters will require unanimous consent.

Statement of Understanding

Participating States through the Expert Group undertake, as a matter of high priority, to hold discussions to identify technical criteria, if any, that better qualify the controls of machine tools. In accordance with Expert Group work practice, this shall be done taking into account the criteria for the selection of Dual-Use goods.

Under the above condition the Validity Note to 2.B.1. is prolonged for an additional year without the possibility for further extension.

2.E.3.f.

Validity Note The control of diamond-like carbon technology in 2.E.3.f. is valid until 5 December 2001 and its renewal for an additional one-year period will require unanimous consent.

Category 3 and Category 5 - Part 1

ITU decontrol Notes to 3.A.1.b.1., 3.A.1.b.2., 3.A.1.b.8. and 5.E.1.c.4.b.

Statement of Understanding

Participating States agree that the definition "Allocated by the ITU" will always reflect the current edition of the ITU Radio Regulations and hence agree that the edition in this definition will be amended immediately when necessary.

Validity Note The decontrol Notes to 3.A.1.b.1., 3.A.1.b.2., 3.A.1.b.8. and 5.E.1.c.4.b. are valid until 5 December 2001 and their renewal will require unanimous consent. If there is no consensus to renew these Notes, the decontrol Notes of 3 December 1998 (WA-LIST (98) 1) will be re-introduced.

STATEMENTS OF UNDERSTANDING AND VALIDITY NOTES

Category 9

9.E.2.
Statement of Understanding

"Development" or "production" "technology" controlled by 9.E. for gas turbine engines remains controlled when used as "use" "technology" for repair, rebuild and overhaul. Excluded from control are: technical data, drawings or documentation for maintenance activities directly associated with calibration, removal or replacement of damaged or unserviceable line replaceable units, including replacement of whole engines or engine modules.

DEFINITION OF TERMS USED IN THESE LISTS

Statement of Understanding

Participating States note that, in these Lists, words and terms appearing under 'Definitions of Terms used in these Lists', if used in their undefined forms, take their common or dictionary meanings. Governments are expected to preserve these distinctions, as far as national languages and legislation allow, when the Lists are translated into national legislation. (See also Note 2 to 'Definitions of Terms used in these Lists').